Land Management in the Punjab Foothills

by

R. Maclagan Gorrie, D.Sc., F. R. S. E.,
Indian Forest Service.

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Price : Rs. 1-8-0.

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LAND MANAGEMENT IN THE PUNJAB FOOTHILLS.

CHAPTER I—Introduction.

Object of this Manual

1·1. The object of this book is to place in the hands of all who may be concerned with the administration of land a concise statement of the true aims of land management in language which can be understood by those who have not had a scientific training in agriculture or kindred subjects. The value of land to the owner, be he a community or an individual, can be realized by putting the land to whatever use will best meet the need of the community as a whole, or will yield the highest rental value, on a *permanent basis*. Much of the present use of land in the Punjab foothills is so destructive and short-sighted that its intrinsic value is steadily deteriorating. Improvement in this respect is possible only if a more correct view of the needs of land management is adopted and officials use their persuasive powers with the zamindars to effect improvement.

Basic Resources must be conserved.

1·2. Soil and water are the basic resources of the country and must be conserved as carefully as possible. Apart from any possibility of industrial development, the Punjab's main activity must always be in the land. The pressure of increasing population neutralizes all efforts to raise the standard of living and of nutrition, while loss of efficiency in the soil itself detracts from the value of any improvements which may be made through better seed collection and heavier yielding types of crop. The virgin lands opened up by our great irrigation projects will soon be fully colonized, after which little fresh ground will be available for further development. Our only alternative must, therefore, be the better organization of the land already in use. It is only through more efficient use of the land's resources of soil and water that the Punjab can remain above starvation level. The immense areas now under perennial irrigation are not by any means sure of their winter water, and one of the objects of this book is to show how the progressive deterioration of the main river catchment areas in the hills endangers the prosperity of these canal colonies.

Aim is Permanent Productivity of Land.

1·3. That the present position is very serious, all experts are agreed. Although misuse of the land and destruction of the soil can only be checked by radical changes in local methods of farming, including the handling of livestock, the

position is by no means hopeless, provided all district officials will combine in handling it properly, basing all their proposals on the need for retaining the land in a condition of *permanent productivity.* In India it has long been recognized that a sustained yield policy is the only correct one for forest management, i. e., the forest is like a bank; it consists of capital (standing trees) which yields interest (increase of timber by growth of trees); we may cut enough to collect our interest but must not reduce the capital value which ought to be maintained. This principle can be extended and applied to the soil under other land uses, including field cultivaton and grazing practice. If any form of field crop or fodder production is to be a real asset to the community, the soil must be maintained in a productive condition and should not be allowed to deteriorate. This is a point which has been stressed in the *Punjab Land Administration Manual,*[1] where in his introduction Sir J. M. Douie states: "the State continues to have a direct and immediate interest in the improvement of the land........(The Deputy Commissioner) must initiate and assist measures to prevent, so far as may be, the loss of crops from causes which are in any degree controllable by man."

[1]For bibliographic references, see page 78.

CHAPTER II—The Various Uses of Land and their Contribution towards Prosperity

A—Farming and Livestock

Intrinsic value of the Top-soil.

2·1. The Punjab has two main divisions of soil: the flat and alluvial deposits of the plains, more than half of which are now under irrigation; and the soils of sloping lands derived from the underlying rock, such as the light loam soils from the granite and gneiss of the Himalayan outer ranges and the friable shales and soft sand-rocks of the Siwaliks and Salt Range. The gently sloping beds of torrent and river detritus which reach out from the foothills far into the plains are an intermediate type and are really new plains alluvium in process of manufacture.

The depth of agricultural soil in the Punjab varies greatly, averaging several feet in the best alluvial plains and in such areas as the Sohan Dun in Hoshiarpur and the Chakwal tehsil north of the Jhelum Salt Range. On most of the sloping land it is only a few inches; the average depth for the whole of the U. S. A. is said to be 7 inches and this can be accepted as a fair average for the sub-montane Punjab also. How long has it taken to make this soil and what does the process consist of? Soils are a mixture of two things: (*a*) vegetable or "organic" remains, so called from the fact that the chemical qualities are derived from the decomposed remains of whatever vegetation previously covered the surface, and (*b*) a mineral part derived from the breaking down of the rocks below the surface into smaller particles. Some of each of these can be dissolved into a fluid and thus made available for the plant roots to soak up as plant food. The accumulation of these two parts is very slow, and in all kinds of natural ground cover, whether forest or grass-land, it may take several thousand years to build up only one inch of soil. It is well known to every farmer that it is the top layer of soil which contains the best plant food, and once this layer is lost or destroyed, nothing can ever replace it, for the lower layers are nearly always less fertile (one of the few notable exceptions being the Punjab plains alluvium which is quite fertile for several feet below). Unfortunately this top layer is very easily lost or dispersed, and the first aim in land management should be to consider how such loss occurs in the different kinds of land use, and how far these losses can be reduced or prevented.

Conservative Cultivation.

2·2. A great deal of research has recently been done in U. S. A. and South Africa to show which types of field cultivation give the best results in terms of soil saved for

the future, but little or nothing of such work has been applied in the Punjab. In certain localities such as Chakwal tehsil north of the Jhelum Salt Range, the cultivation is of a very high order from this point of view of soil saving, but this is by no means universal and appears never to have been officially encouraged except as a personal interest of certain officers, whereas such a vitally important feature of field practice ought to be placed at a premium. This can be done through sustained official encouragement by remission of revenue or cash rewards to individuals or villages whose fields are outstandingly well prepared. No hard and fast rule can be laid down nor can any one single practice be recommended for the province as a whole, but local study will show by what means the lay-out and levelling of fields, the building of terraces or ridges, and the method of ploughing can serve to save the soil from being washed away and increase the amount of moisture which is soaked up by the soil.

Destructive Methods.

2·3. Much of the *kalsi* or *karali* cultivation of the hills is very destructive because it is still virtually the old fashioned shifting cultivation and essentially a transient form of agriculture. Usually, however, the revenue settlement, presuming that all cultivation is permanent, has allotted permanent boundaries to fields as well as to grazing lands and forests. All *kalsi* cultivation, and particularly the rapidly extending potato crop in the high hills, is so improvident and wasteful of soil that the average life of a potato field, unless very carefully terraced, is less than 10 years, after which the ground is too poor to be ploughed and reverts to grazing and eventually becomes a stony scree. At this pace the whole cultivable area is rapidly exhausted and further suitable areas can only be made available by disforestation or some other revision of what was ostensibly fixed as a permanent allocation of the remaining land to other purposes. Possible remedies for this very serious state of affairs are discussed in paragraphs 7·2—7·3 and 7·16—7·17.

Soil saving value of crops

2·4. Apart from its value for cash or food to the grower, every field crop has some value in stopping the loss of soil which inevitably occurs when heavy rain beats upon bare soil and carries it away as muddy particles in the surface flow. When bare land is ploughed, the broken surface absorbs more rain and prevents sheet-wash for just so long as it remains absorptive and rough, so that repeated ploughings are effective. If the young crop springs up quickly

and forms a dense mass of vegetation, it prevents run-off more effectively than can a slow growing and scattered distribution of plants. The season of growth is also important in so far as a good plant cover produced before the start of the monsoon will reduce the soil wash at this season, while crops sown at the monsoon and only sprouting later leave the soil exposed at the worst time. The condition in which the fallow is left after harvesting, and the amount of vegetable matter left in roots and stubble, also affect the amount of subsequent soil loss. Taking all these factors into consideration the following list classifies the common Punjab crops roughly as *Soil Savers* the first being best and the last being the worst :—

Permanent hay fields on terraced land,

Sorghum and leguminous fodder (shaftal, etc.),

Unirrigated rice,

Irrigated rice,

Dal—mash, moth and matar,

Sarson,

Gram,

Chari and jowar,

Wheat and other cereals,

Chillies and vegetables,

Bare fallow on terraced land,

Maize and sugarcane,

Cotton,

Buckwheat and millets,

Potatoes.

Bare fallow on unterraced land.

Better Field Practices.

2·5. It is obvious that the crops most grown by the whole community must be those which yield the best returns in food or cash value under local conditions of climate and available moisture. It is unlikely that any immediate change in the kind of crop grown can be brought about except by economic changes. The alternative lines of improvement which can be introduced therefore lie in better field prac-

tices. Some of these are defined below, but a more detailed discussion is given in Chapter VII :—

(*a*) *Benching or ridging*—'*Watt-bandi*' is the Punjab[i] equivalent for what Americans call 'benching.' Current European phrases for this are 'contour ridging' or 'contour terracing'. The main idea in them all is that each long slope is broken up into a series of flatter terraces by means of ridges or built up embankments which run across the slope (along the contour). These ridges may be broad-based low humps which do not interfere with ploughing or they may be sudden changes of level which isolate each terrace and make it a separate small field for ploughing. Broad-based terraces are useful only in deep soil and are not feasible in shallow soils, where turf walls or stone walls are better.

(*b*) *Terracing*—Where ridging entails the building of walls or embankments across the field surface, stone or turf walls can be introduced to support the terrace behind. (See paragraphs 7·2 and 7·3).

(*c*) *Field drains*—See paragraphs 7·8 to 7·10.

(*d*) *Strip Cropping*—Large fields of valuable crops such as maize or potatoes are divided up by making contour strip sowings of soil-saving crops such as grass or shaftal. Some of the soil and surface wash lost from the valuable crop is caught and held by the strips. For broad fields this method is more effective than rotating or changing the whole crop during a period of years. (See paragraphs 7·5 and 7·6).

Sowing fallow—If land is to lie idle and empty for some time after harvesting, it should be sown with grass or any other cheap seed which will produce a plant cover upon it. Such sowing may be done either when the main crop is sown or immediately after it is harvested. In America *Lespedeza* and many other leguminous plants have been bred specially to give a cheap and plentiful seed supply for this purpose. (See paragraph 7·11.')

2·6. The question of manuring is an immensely serious one for the Punjab farmer, particularly in those districts where much of the cattle droppings which ought to go to the fields is used as dung-cakes for fuel. This exceedingly wasteful habit is the antithesis of good agriculture and every effort must be used to put a stop to it. No district can ever be prosperous as long as the burning of dung-cakes deprives the soil of badly needed plant food. The cure is to be found in growing more trees for fuel, and in the wider use of the hay-box for keeping milk, etc., warm. The tethering of animals in fields and feeding with cut fodder will secure a better return of manure than is given by uncontrolled grazing. The shortage of manure could to some extent be met through a wider use of compost pits, in which all forms of waste from weeding, straw, pine needles, etc., can be turned into efficient plant food. This is a more economical method than applying the manure itself direct to the fields. (For further details see paragraph 7·13).

Manure Supply.

2·7. The other main branch of farming, namely live-stock, is an even more potent factor in the future prosperity of the Punjab. If the livestock management is brought on to sound lines it will guarantee prosperity even when crop prices are poor, but if it is neglected, and uncontrolled grazing of large herds continues, both milch cattle and plough stock will inevitably deteriorate. It is a striking fact that in countries such as South and East Africa and U. S. A. the cattle industry is prosperous with a minimum of common grazing land and full use of stall feeding; whereas the very worst types of Indian cattle are seen in those areas such as the Kangra and Rawalpindi districts where large areas of free common grazing land are available and little or no stall feeding is customary.

Livestock.

Of the well-known breeds of cattle, the Hissar animals have well-conducted grazing arrangements, while the Dhanni although bred where there is practically no common grazing ground left, have individual animals kept apart from the ordinary herd and stall fed by the family to which they belong. Where the people have been forced to rely entirely upon stall feeding they have naturally concentrated upon fewer and better animals. On the other hand, in many districts the people are so poor that they need all their land for growing food crops and cannot be expected to spare land for cultivated fodder crops. As the farm

community alters towards the grazier type the daily milk output per cow drops from an average of 16 or 20 lbs. of milk to as little as ¼ lb. The average price for slaughter cattle from forest areas is about Rs. 10 whereas cattle reared on cultivated land and fed on fodder crops and crop residues are worth a great deal more, averaging probably Rs. 30. We should therefore make the best use possible of all 'waste' land (uncultivated) for the production of cut fodder rather than grazing, and restrict the grazing to whatever part of the waste land is actually necessary to the cattle as an exercise ground.

Cattle fodder.

2·8. It is becoming recognized by authorities everywhere that milk diet is of the utmost importance in raising the standard of human nutrition, and the quality as well as the quantity of the milk output deteriorates wherever the animals are not properly fed. Apart from grazing, the food resources for animals comprise :—(*a*) straw and stubble from crops such as rice, wheat and sugarcane ; (*b*) leguminous and other fodder crops ; (*c*) cut grass and (*d*) tree lopping. Rice straw is the mainstay in many districts but is not in itself a *maintenance ration*. Lander and Dharmani (2) place the value of Kangra rice straw as being well below this standard, which is the minimum digestible protein needed to keep a cow fit : they also indicate that wheat straw is somewhat better in food value, but the amount available is sufficient only for a short time after each harvest. The chief fodder crops are juar (*Andropogon sorghum*, Brot) and in irrigated tracts berseem (*Trifolium alexandrinum*), shaftal (T. *resupinatum*), and lucerne ; again the amount of these fodder crops is in inverse proportion to the amount of wild grazing land available, and the poorer districts have such a hard struggle to find enough land for their own food crops, that they cannot grow any fodder. This is a point which many animal husbandry enthusiasts have failed to grasp. (See Chapter VIII amd Sir A. Olver's note printed in Appendix II).

Grass-land Improvement

2·9. The value of cut grass is also rather low in the foothill areas, partly owing to the natural poorness of the grass crop from land which is heavily overgrazed for at least nine months in the year, partly owing to the method of harvesting the grass. At the time when hay ought to be made, in the months immediately following the monsoon, the cultivator is busy with his autumn ploughing, so the cutting of grass is inevitably delayed until only the dry sticks of the grass crop are left. As it is not possible to alter the

agricultural calendar, progress appears to lie along the lines of grass improvement and cultivation by contour ridging and by any other means which will keep the grass green for a longer time. The possibilities for the improvement of wild grass-lands along such lines are tremendous, but are so far practically untouched. This is dealt with in detail in Chapter VI.

2·10. The intense demand for fodder is responsible for serious deterioration of all waste lands subjected to common grazing. Every kind of livestock competes for a living and the ground cover is gradually but surely destroyed. Of the various factors affecting the plant cover, such as clearing of grass-land or forest by burning or felling, ploughing, grazing, etc., grazing is probably the most widespread and most insidious. Constant heavy grazing by underfed animals, such as occurs on village common lands throughout India, and particularly during the driest periods when the vegetation is most easily injured, leads inevitably to the thinning out of the vegetation and to compacting the soil into a solid mass, so that the reduced cover is less capable of checking surface run-off and the altered soil profile below is less capable of absorbing it. Loss of cover leads to soil erosion by surface washing of the loosened top-soil, leading inevitably to gullying and reduction to stony screes. This phase of the grazing problem is dealt with in Chapter VI. For the present discussion it is sufficient to realize that uncontrolled grazing is the most uneconomical and destructive use to which land can be put, wherever there is a quick run-off.

Grazing Causes Erosion.

2·11. There remains the problem of the goat, which is the Punjab's most efficient engine of destruction. In some advanced countries goat-browsing is prohibited by law and goats may only be kept stall-fed; where this is followed the domestic goat is a source of useful revenue to the owner and its destructive habits are curbed. In Cyprus goatherds are being given a small-holding in exchange for giving up their herds. In many other countries drastic steps are being taken to bring goat browsing under control. Goat-browsing can be justified only where the country is incapable of supporting milch cattle, but this is seldom the case in the Punjab, which is essentially fit for cattle-rearing. Even under a system of rotational closures it is difficult to control goat-browsing and restrict the damage to a reasonable amount. Goats are

Goat Browsing.

particularly destructive in the foothills where they eat any woody plants; they destroy what the sheep leave. In Kangra scrub forests 10-year closures have not been sufficient because young trees of less than 10 years of age are destroyed by the browsing goat, and so the better kinds of tree which might produce timber and fuel are prevented from regenerating themselves, and the scrub jungle consists only of worthless thorny bushes which usurp the place of the much needed grass and trees. The possibilities of controlling goat damage and of improving the goat industry, also the extent to which it is advisable to replace goats with sheep are dealt with in paragraphs 8·17 to 8·20.

CHAPTER III—The Various Uses of Land and their Contribution towards Prosperity.

B—Forestry and Water Conservation.

3·1. It is hardly necessary to detail all the obvious uses of forest produce. The manifold uses to which wood is put by the agricultural population for house building, furnishing, ploughs, carts, fuel, etc., are fully known, though perhaps it is not so generally realized how far tree fodder, forest grasses and shrub growth contribute to the feeding of livestock. The less direct influences of forest in reducing climatic extremes and in stabilizing the water supplies of a country are also less appreciated than they should be. Most authorities agree that it is desirable to have at least 25 per cent of every country maintained under forest, but in the case of the Punjab the actual amount of forest is 5 per cent and in the North-West Frontier Province only 2 per cent.

Forest Influences.

3·2. Not only is the actual area of demarcated forest far too small to satisfy this requirement, but much of the land classified as "forest" is incapable of producing crops of commercial timber. It is, however, of considerable value for grazing, fodder production, flood control, water conservation, and game management including fishing, or should be, were it not that the grazing use has been allowed to obscure these other possibilities for making use of such land.

Small Forest Area.

3·3. Most of the timber-producing forests in the Himalayas are owned by a Government agency, either the Punjab Forest Department or one or other of the states, and are being maintained under working plans which guarantee that they are worked on a basis of permanent productivity or at least that the existing crops of trees will not be sacrificed without some attempt being made to replace them. The forest estate must be regarded as a bank, from which the forester may remove only the annual or periodic interest, or its equivalent in mature trees, and must not reduce his capital (see paragraph 1·3).

Timber producing Areas.

3·4. The output of many forests calculated in this way may not, however, produce any cash because the policy of the Government of India, as laid down in Circular 22-F of 19th October, 1894 and reproduced as Appendix I of this

Management of Government Forests.

book, is that considerations of Government income should be made secondary to the satisfaction of right-holders' and local requirements. Thus a great deal of departmental activity even in timber-producing forests may not produce any revenue. The working plan has also to provide for the exercise of local rights in grazing and these are very often so liberal under the Forest Settlements of 60—80 years ago that it is exceedingly difficult to provide for the closures which are necessary to allow the young crop of trees to be produced and established on the ground. This is particularly the case with tree species easily damaged by fire or browsing in their young stages, as these require 20 or even 30 years' closure before the young plants are out of danger.

Private Forestry.

3·5. Private forestry therefore finds no outlet in the Punjab high hills, but in the lower hills and the plains there are very promising possibilities for private estate afforestation to produce fuel and small timber, establish shelter-belts to reduce sun, wind and hail damage to fruit gardens and farm steadings, and grow a variety of tree crops which will yield fodder and fruit.

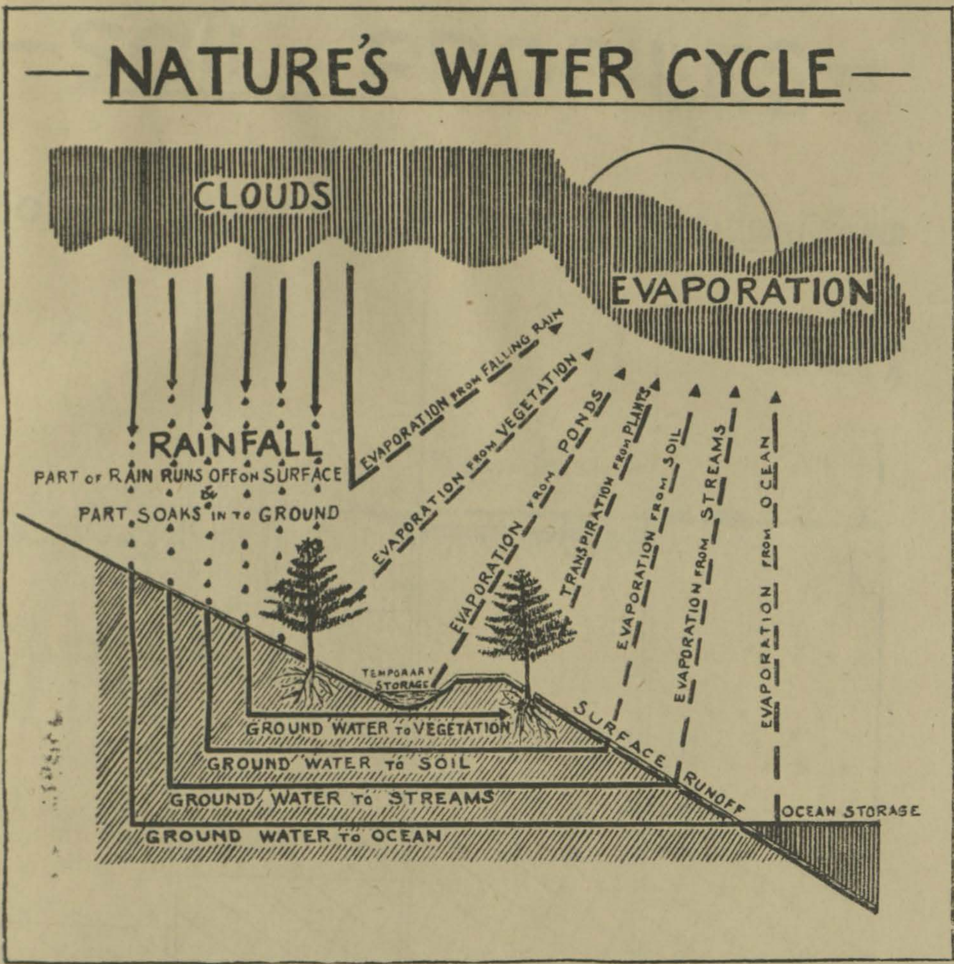
Village Fuel Plantations.

3·6. The pernicious habit of burning cowdung instead of using it as manure in the fields has been commented on in paragraph 2·6 and the obvious cure is to get each village to grow its own fuel in small plantations which could either take the form of a shelter-belt where a shelter is likely to be of value, or else as village plantations formed on part of the *banjar shamilat* at present devoted entirely to grazing. This is dealt with more fully in Chapter IX as it is a form of village uplift which must appeal to all clear-sighted people, and once its value has come to be recognized will be so much in demand that every officer in any way connected with land management will be expected to take charge of shelter-belt and fuel plantations.

Supply of Plants and Advice.

3·7. It should be the policy of Government to enlist all elements of the community in a campaign of afforestation. Funds cannot be made available lavishly, but technical help should be available from the Forest Department to advise, and to provide plants, wherever a village or other unit is prepared to do its own planting. Afforestation carried out by individuals and communities can be made financially profitable as well as meeting some of the pressing economic needs indicated above.

Fig. 1.



NATURE'S WATER CYCLE
CLOUDS
EVAPORATION
RAINFALL
PART OF RAIN RUNS OFF ON SURFACE & PART SOAKS IN TO GROUND
EVAPORATION FROM FALLING RAIN
EVAPORATION FROM VEGETATION
EVAPORATION FROM PONDS
TRANSPIRATION FROM PLANTS
EVAPORATION FROM SOIL
EVAPORATION FROM STREAMS
EVAPORATION FROM OCEAN
TEMPORARY STORAGE
GROUND WATER TO VEGETATION
GROUND WATER TO SOIL
GROUND WATER TO STREAMS
GROUND WATER TO OCEAN
SURFACE RUNOFF
OCEAN STORAGE

3·8. Conditions in the Punjab are peculiarly favourable for such development. A constantly increasing population needs fuel in enormous quantities ; better farm buildings and more industrial undertakings must enhance the demand ; the growing fruit trade requires packing crates ; forest authorities all over the world regard the supplies of soft-woods with anxiety and prices are practically certain to increase for even the inferior kinds of wood ; wood preservation treatment now gives some guarantee that cheap woods and bamboo can be used for many purposes for which they were previously thought too quickly perishable.

Fresh Uses for Wood.

3·9. The Punjab's main problem can be summarized as lack of soil in the hills and of water in the plains, for even in the irrigated tracts prosperity is restricted by the increasing shortage of water for *rabi* (winter) crops. These two may not at first sight be identical but a consideration of the water cycle will show that it is. (Fig. 1.) Air moisture drawn from the sea is dropped on the land as rain from clouds under given atmospheric conditions. Some portion of the falling rain is held by the ground surface and sinks in while the rest runs off as surface drainage into the nearest stream and thence to a river and the sea.

Water Conservation.

3·10. The supply of water in wells and permanent springs depends directly upon the first of these two, because the underground " water-table " is fed and maintained by whatever water sinks through the soil. (Fig. 2.) The soil acts as a sponge in passing surface drainage down into the rock crevices below. Where there is no soil there is no sponge action, and where the soil is a bare surface without any plant cover as in fallow fields the sponge action is also very slight, for the surface of the soil is caked into an impermeable crust, off which the water flows as if from a cement or iron roof. The sponge action depends upon the amount of plant cover, being best under canopied tree forest with a deep undisturbed layer of rotting leaves on the ground below the trees. Even in prolonged and torrential rainfall the surface run-off from such forest is distributed over a long period and a large percentage of the arrested rain is passed underground. On the other hand if it has been much opened by lopping, fire, browsing, or very heavy fellings, or grazed until the floor is beaten into a hard cake of clay, the forest is no longer as capable of dealing with rainfall, and much more runs off immediately as surface drainage

In the same way grass-land, though not actually as effective as good forest in absorbing rain-water, is a very good substitute, provided it is given a chance of building up a spongy soil and a good thick plant cover. But the more heavily it is trampled and the thinner it becomes through continuous grazing, the less efficient it must be in stopping floods and passing water underground. In paragraph 2·4 above is given a list of field crops in order of their priority for saving soil, and roughly they take the same order of priority in an estimate of their value as conservers of surface run-off.

Run-off Control.

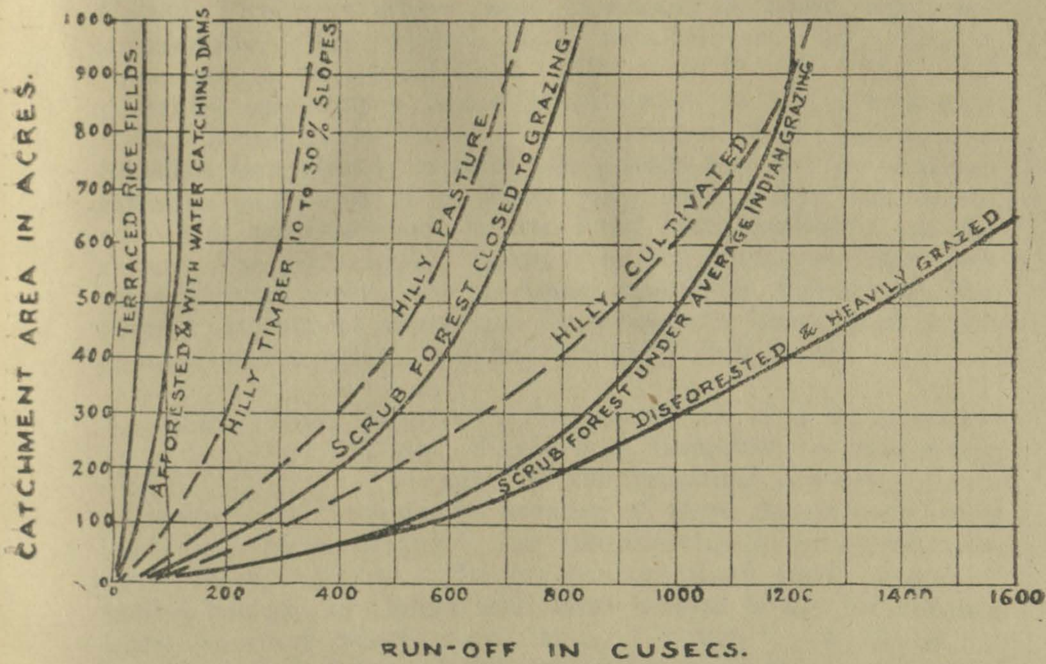
3·11. In American data, the ordinary field crops are assessed as of less value for water conservation than are grazing grounds, but the reverse is the case in the Punjab. (Fig. 3.) Even where terracing is not as good as it might be, a series of small terraced fields is more efficient in stopping surface run-off than is a corresponding area of heavily grazed land carrying only scattered bushes and poor grass on an uninterrupted slope. Run-off data collected by the Irrigation Branch from torrents of the Pabbi Range, Gujrat district[3] show clearly that the peak flood of immediate surface run-off is much more serious from heavily grazed land, increasing by recognizable stages of damage to the plant cover. Compared with the gentle run-off from a fully afforested area yielding 100 cusecs per square mile, protected scrub jungle yields 600 cusecs, and the same kind of ground open to considerable grazing yields 1,000 cusecs, while an area entirely open and badly denuded by constant heavy grazing, browsing, and lopping, yields 1,600 cusecs. In this last case the floods actually measured represent about 90 per cent of the heaviest storms which fall in the area, showing how very seriously grazing and other misuse of the scrub jungle interferes with its function of water storage. Run-off of this latter type naturally exaggerates the intervening periods of drought because spring supplies and underground water-table both deteriorate.

Water-table for Wells.

3·12. Immense areas of the Punjab plains now depend upon perennial canal irrigation but are by no means sure of their winter water, and the progressive deterioration in the condition of the high hill and foothill catchment areas may further endanger the position. Apart from the Thal and Bhakra projects further irrigation development is restricted to the pumping of well water by hydro-electric or animal power, but experience in the Jullundur *doab* indicates that the underground water-

Fig..3

COMPARATIVE RUN-OFF *for* AMERICAN & PUNJAB CONDITIONS.



AMERICAN DATA FROM C.E. RAMSER'S CURVES.— — — — —

INDIAN DATA FROM PABBI HILLS TORRENTS MEASUREMENTS BY IRRIGATION BRANCH. } ————

table there has already been so badly affected that further pumping is likely to exhaust the available supply. In this respect the Punjab hills are not comparable with those of the United Provinces where well irrigation is being extended successfully. The hydrological balance in the United Provinces is well established, with more frequent rains and generally speaking a better plant cover in the catchments than is found in the Punjab. A comparison of the Saharanpur Siwaliks immediately east of the Jumna and of the Ambala Siwaliks just west of it shows very clearly the cumulative effects of protection on the one hand and denudation on the other. The hydrological balance in the Jullundur *doab* has already been upset, due to some extent to misuse of the Siwalik catchment areas, and the price now being paid is the steady but cumulative deterioration of well levels.

Industries Affected.

3·13. Even industrial activities are affected by alternating floods and droughts, economically because of the resulting poverty of the zamindar, and technically because of their dependence upon sustained water supplies for manufacturing processes and hydro-electric power. The greater the flood peak of uncontrolled run-off, the longer and more serious is the intervening water shortage which shows as a "trough" or dip in a graphical illustration of the quantities available from any of the larger rivers.

Malaria reduced by Run-off Control.

3·14. Dr. C. Strickland of the School of Tropical Medicine, Calcutta, claims that the incidence of malaria will be greatly reduced in the lower lying areas if effective flood control works are carried out in the foothills and small catchments. By means of contour trenching the run-off from torrents can be delayed and a larger amount of water allowed to soak into the higher slopes, thus avoiding the collection of stagnant pools in the lower ground where the mosquitoes breed.

Silting.

3·15. The various irrigation projects have so far depended upon the free flow of a river, and so have escaped the serious problems of the silting of reservoirs which has spoiled the economic success of many water-supply projects in other countries. Many of the great American projects have been seriously interfered with or entirely ruined by the rapid silting up of their reservoirs, and it is for this very reason that Punjab projects such as the

Bhakra Dam have had to be delayed or discarded. The Uhl Hydro-electric project also cannot reach its full planned development without making some provision for securing a better winter water supply, either by reforestation of the catchment area or by constructing a dam. Another alternative is a separate and supplementary coal-burning plant on the plains. But whatever plan is adopted, an otherwise sound engineering plan is likely to be very severely handicapped by the shortage of winter water, due to improvident and thoughtless denudation of the catchment area by primitive hill farming methods.

Value of Water Catchments.

3·16. The value of the hill catchment areas assessed purely as water-catching basins already far exceeds their value as represented by the local farming and grazing communities which they maintain, and with increased industrial and city development this difference will increase. In the case of the Uhl catchment, an area of 150 square miles yields to Government an income of Re. 0-0-3 per acre in land revenue and grazing fees and maintains a population of less than 30 per square mile in a state of dire poverty. The money invested in the Uhl project, however, amounts to Rs. 730 per acre of the catchment area, though nothing whatever out of this has so far been spent upon the catchment area itself, and no action has been taken to replace the primitive cultivation with a better plant cover which would guarantee a sustained winter flow.* This illustration is quoted to show the fallacy of allowing a few primitive graziers to exercise their so-called "rights" of destructive exploitation of the natural plant cover, at the expense of a very much larger community,—in this case entailing as it does the future prosperity of the greater part of the Punjab or at least all those parts of it where electrification is being developed.

**Fool-note*—Steps have since been taken to evict resident goats and sheep and prevent the seasonal migration of foreign flocks. This has improved the condition of the forest and alpine pasture but no control of cultivation methods or reduction of area cultivated has yet been introduced (1946).

CHAPTER IV.—THE VARIOUS USES OF LAND AND THEIR CONTRIBUTION TOWARDS PROSPERITY.

C.—Other Activities.

Communications: Railways, Roads, Canal Banks, etc.

4·1. Of the land allocated for these uses, a fairly large percentage is not actually used for the purpose in question, for instance railways have large embankments and waste ground, and roads and canal banks have large areas reserved for future use as borrow pits. Such land must in the aggregate be a very large area, and it should be the duty of the authorities responsible for each to see that it is as far as possible put to productive use, consistent with the main requirements to which the area has been devoted. The possible uses are : trees for shade, timber, fuel, or fruit ; grass cutting or grazing ; other bushy crops ; the cultivation of annual crops is not desirable in such places. The growing of trees on such land if properly organized as regards planting and marketing can be made a paying proposition throughout most of the Punjab. Many cases are on record where Punjab district boards have realized as much as Rs. 100 per standing tree of shisham from road side avenues aged 60—80 years.

Use of Waste Land.

4·2. In the case of railways, grazing is barred owing to danger to traffic, and inflammable crops such as grass or hay are also out of question so that tree or bush crops appear to be the only alternative. The Forest Department has attempted to establish tree crops for the North-Western Railway on a number of their arid waste areas, and some success has been obtained with the Mexican *mesquite* (*Prosopis juliflora*). Choice of species is restricted usually by absence of water and by exposure to frost, so that only the hardiest local species can be used, and these are mostly handicapped by their very slow growth.

In the case of roadside land, grazing is again a doubtful expedient, particularly in view of the trouble caused to modern fast traffic by stray animals on the highway, but grass-cutting is an obvious way of utilizing any good grass. As a rule, however, there is so much promiscuous grazing that grass only forms a hay crop if it is protected as in the case of areas fenced for tree planting. Some form of fencing

is essential for at least the first ten years of plantations for roadside avenues, and a single long fence for an area is as a rule much more satisfactory than cages built round individual trees ; incidentally continuous belts of fencing make the roads appreciably safer for motor traffic by restricting the movements of stray animals.

Interference with Natural Drainage.

4·3. In the case of both railways and roads outside the dead flat ground of the irrigated plains, considerable interference with the natural drainage is caused, particularly where a track or road is built with deep cuttings or high embankments. Such places collect an amount of surface drainage which is led into one or more special culverts or drains. These as a rule are paved in the immediate neighbourhood of the road, beyond which the great accumulation of water is turned loose into natural drainage channels, which were not intended by nature to carry so much run-off. The result is that such natural drainage channels start cutting and eroding very much faster, and this may have very serious consequences in neighbouring agricultural land. The same thing occurs where a road built on a long gradient across a hillside provides only one large culvert for the cross drainage from a series of small stream-beds ; the run-off from such places gives rise to uncontrolled erosion on the hillside below.

Consolidate Earthworks.

4·4. Such effects can be minimized if the engineers in charge of construction and repair would devote some attention to the effects of their work beyond the actual confines of the work. Drainage should not be unduly concentrated except where natural drainage channels can carry the extra run-off without starting fresh erosion, as in rock-bottomed streams. Where great banks of " made earth " are necessary in construction they should be helped to reclothe themselves naturally in order to reduce the washing effect of rain upon the surface. The re-vegetation of such slopes is a rather specialized form of afforestation. In such soft earth it is desirable to anchor the soil as quickly as possible while the slower growing and more permanent plants are establishing themselves. A method employed in California and successfully tried on the Jhelum Railway bridge embankment is to revet the slopes by burying long bundles of twigs or cane grass bound into thick ropes, and pegged down along the contour with cuttings of willow, castor plant, *banna* (*Vitex negundo*) or

any other stick which will take root readily as a branch cutting. The bundles are buried just level with the general slope so that they stabilize it without forming any obstruction. The urgent need for some sort of plant cover to protect the exposed soil is met by line sowings or broadcast sowings of wheat, barley, mustard, or any of the locally used plants of the pea or dal—mash type which can be depended on to produce an immediate crop. These serve to hold and consolidate the loose surface until the slower growing plants locally suitable for a permanent tree or scrub-jungle cover can be established by sowing or transplanting.

Canal Avenues.

4·5. Most of the above remarks apply with equal force to canal banks and canal roads, though the adjoining ground here lends itself more readily to leasing out for grazing. Some magnificent canal-side plantations and avenues date from the enthusiastic planting done by several early Punjab engineers and the remains of these have now been incorporated in recently prepared working schemes which provide for the removal and replacement of overmature trees and the planting of other suitable canal-side lands.

Fruit Growing.

4·6. A number of useful pamphlets on this subject have already been issued by the Punjab Agricultural Department and their fruit specialist is available for consultation on any proposed schemes. The possibilities for the cultivation of fruit in all parts of the Punjab are enormous but each neighbourhood must be specially studied in order to know which of the many fruit crops are likely to be most useful and most permanent. All slopes must be properly terraced before the trees are planted. The promiscuous planting of unsuitable species is not only uneconomic but is likely to encourage the spread of plant disease and pests. The experiences of fruit growers in Palestine and California, both of which have climates somewhat similar to the Punjab, show that many kinds of valuable fruits can be cultivated with a little care.

Care of Orchards.

4·7. No agricultural community can be fully productive if it fails to use its land to the fullest. The growing of fruit, firewood and timber along with its field crops is an obvious method of utilizing waste ground and steep field terraces, which cannot carry ordinary crops. On the other hand the use of ground entirely for the growing of fruit is not sound, and intervening

spaces between orchard trees should be utilized for vegetables and fodder. The grazing of orchards is not advisable owing to the damage done to the trees and the compacting of the ground by the stamping of hooves. Orchards can usually be improved by providing them with shelter-belts.

Multiple use of Land.

4·8. One great disadvantage of the present organization of Government is that it is nobody's duty to look after land development as a whole. Various departments have their own limited sphere of land work, e.g., the Agriculture Department looks after crop improvement and the prevention of pests, the Veterinary Department looks after the health of livestock, the Forest Department looks after demarcated forests, and the Revenue Department collects the land revenue from cultivation. Nobody, however, is responsible for seeing that each bit of land is put to reasonable and permanent use on the basis of the greatest good for the greatest number, and until some such body is constituted and given some executive authority, there is little hope of this being done. This is dealt with later in Chapter VIII. America is now paying great attention to the possibilities of the *multiple use* of land, because a great many mistakes have in the past been made through allowing a single use to destroy the value for all other alternative purposes, and ultimately for the principle single use itself. Examples are found in (1) the over-grazing of publicly-owned grazing land, thus destroying the cover and rendering it useless for forestry or shikar or any other purpose ; (2) mining dumps of useless stone being deposited on valuable land capable of growing fruit, etc. ; (3) smelter fumes from foundries poisoning the surrounding vegetation and exposing the land to accelerated erosion ; (4) the destruction of forest (a permanently productive asset) in favour of inferior and transient cultivation which may only last a few years but which destroys the accumulated soil. The object rather should be to encourage the use of the land for as many purposes as can reasonably be combined upon it.

CHAPTER V.—CLASSIFICATION OF LAND AND EFFECT OF PAST CONTROL

5·1. Land revenue is "the first charge upon rents, profit, or produce" of an estate or holding, and all revenue textbooks emphasize that land revenue is not a land tax but a rental paid to Government as the ultimate owner of all land. The activities of Government revenue collection are however mainly restricted to cultivated land, which is divided and classified under a minutely detailed system, but for uncultivated land only a general indication of its present use is given. Its potentialities for future development should be known and proposals are made below for more detailed classification in each district.

Legal and Revenue Classes.

5·2. The various classifications already in use give a very clear indication of the present value of the soil in terms of crop production. They include (*i*) the type of watering, whether by rainfall, well or other irrigation, (*ii*) the type of manuring (in Frontier *bari* and Kangra *basi*), (*iii*) the number of crops taken annually (*ekfasli, dofasli*) and (*iv*) a rough soil analysis varying in each district according to the locally recognized types. (Paragraphs 259—265 of Douie's *Punjab Settlement Manual.*) ([1a]) This classification is applied strictly *on the present condition of the land* to give the current crop value, but is not intended to show progress or retrogression.

Cultivated Land.

The patwari's field book shows the fate of individual fields which through neglect or bad husbandry have been allowed to deteriorate or go out of cultivation and such losses should be summarized in the Abstract Village Notebook as outlined in paragraphs 405—407 of Douie's *Punjab Land Administration Manual.* Notes by the revenue officers bearing on any sheet-washing or gully erosion observed by them would ensure a continuous history for each group of fields affected by erosion. At present any land that is improved by the zamindar tends to be reclassified for a higher assessment as soon as it is qualified for entry into a higher type; to avoid this discouragement some remission of land revenue or the granting of prizes would encourage competition amongst zamindars towards a better standard of field cultivation and maintenance, particularly in view of the fact that on many types of soil the making of *watts* reduces the fertility of the field for at least the first two years of crops.

5·3. In this connection Douie states that it is doubtful whether the distinction in vogue in these districts (north of Salt Range) between embanked land or *las* and ordinary loam or *maira* is worth retaining in our records, for land owners often refuse to make any difference between them in distributing the revenue over holdings. If a history of each individual field were on record over a long period, it would probably be found that most of that embanked land is still under cultivation as such, but many of those non-banked fields of equally good soil have since retrograded into a lower class such as *rakar*. The memory of the individual cultivator is short and the change is so gradual that he has not become aware of it, but lack of proper terracing even on practically level ground leads inevitably to deterioration.

Embanked fields (*wattbandi*).

5·4. Again in poorer classes such as *rakar* and *karali* or *kalsi* (cultivation in poor stony ground and on fairly steep slopes, respectively) the ordinary revenue records give no detailed history of the individual patch of field, so that its story is not known. It is not generally appreciated what a very large amount of the old-fashioned destructive *shifting cultivation* is still carried on to-day. Even in districts where *nautor* sanctions have to be obtained for breaking land for the first time, sanction is merely a formality except in a very few instances where sanctions for *nautor* on tree-bearing ground have to go through the local forest officer. No restriction is attempted to prevent the breaking of steep slopes, and no data are available to show the steepest slope that can be properly terraced at a cost which will be economically feasible. What is needed is a local set of rules for the guidance of *patwaris* and others (*i*) to prevent unduly steep land being broken at all (a slope of 1 in 4 is suggested as being the maximum for average Punjab soils, and 1 in 6 for Siwalik sandstones, gneiss, and shale) and (*ii*) where steep land is already broken by ploughing, to insist upon its proper terracing within a given period (say three years from the local application of the rule), failing which it should be turned into hay fields for grass-cutting.

Breaking of Fresh Land, and Rules for Slopes.

5·5. The standard classification provides only for three classes, namely : (*i*) *banjar jadid*, new fallow, not sown for four previous harvests ; (*ii*) *banjar kadim*, old fallow ; not sown for eight previous harvests, and all cultivable waste whether previously ploughed or not; (*iii*) *ghairmumkin*

Uncultivated Waste Classes.

barren, uncultivable land, includes roads, buildings, river-beds, graveyards, etc. The classification of all grazing land falls in these groups but is dismissed by Douie with the following short note (para. 267) : "It is proper to classify all grazing land of fair quality as *kadim*, even though existing conditions of rainfall and subsoil water level preclude its cultivation....It is necessary to instruct *patwaris* carefully as to the distinction between *kadim* and *ghairmumkin*, otherwise they are apt to record land which is useless either for tillage or pasture as *kadim* because it yields for a brief period in the rains a scanty supply of poor grass." We thus have a classification which admits of only one productive use for the land, namely, cultivation, but in the last resort its class is decided by the condition of the grass crop on it. This sounds illogical, but in practice works fairly well, because the zamindar usually knows from bitter experience what land will produce a crop and what will not. Unfortunately the pressure of necessity and want often drives him to ploughing steep or stony ground which in his heart he knows cannot repay him for his trouble, and which would be better left under grass.

Disappearance of *Shamilat deh.*

5·6. The old convention was that a definite percentage (generally 2/5th to 1/10th) of the total land in each village should be reserved as *shamilat deh* for common grazing, and this gave some guarantee that the poorer land would be left under grass. Now, however, this convention is no longer observed, with the result that existing grazing grounds are becoming smaller and therefore more and more congested and overworked. At the same time more of the steep and really uncultivable land is being ploughed at irregular intervals wherever it has been left long enough to produce a few tufts of grass and bushes which, when ploughed in, serve to some extent as an organic manure.

Classification of Grasslands.

5·7. The possibilities of improving the natural grass-lands by means of contour ridging, etc., are dealt with in Chapter VIII, and at this point it is desired only to point out that some better classification of grass-land than that described above should be worked out, so that the promiscuous destruction of grass-lands can be prevented. It is suggested that two additional classes be recognized and mapped at forthcoming settlement revisions, namely (1) *khas ghasni*, lands which can produce a really good crop of cut grass and which, though strictly cultivable, should be preserved as

hay fields ; (2) *dhalwan*, all ground above a slope of, say, 1 in 4, which is too steep to be economically worth terracing and which, therefore, should be kept out of cultivation altogether ; where the soil is easily disturbed by grazing animals, as in the case of Siwalik sandstone, *dhalwan* should be reserved against grazing also.

Forest in Village Lands.

5·8. Village lands bearing any kind of tree growth are shown in revenue records as *dakha darakhtan*, but as a rule no special treatment is prescribed and they are treated merely as grazing grounds. In the case of chil pine the shade of the pine is detrimental to good grass growth, so the villager takes very good care that the old trees are gradually eliminated and that no young growth is allowed to come up to take their place. Tree growth of practically all species is peculiarly sensitive to goat-browsing, so that the very few species of tree and bush which are unpalatable to the goat are the only ones found in heavily browsed areas ; for the foothills these are *sanatha* (*Dodonea viscosa*), and *bekhal* (*Adhatoda vasica*) ; *garanda* (*Carissa spinarum*) often persists in spite of heavy browsing ; all three are practically worthless except as a rather inefficient soil cover. The very large areas covered by this type of growth are an epitome of the destruction caused by wrong use of land, for this poor scrub jungle is not by any means the same as the original primeval jungle which has been destroyed. For the Punjab and Frontier and adjoining Indian States the total of such degraded scrub forest must be in the neighbourhood of 20,000 square miles, and most of this could be economically productive and of much greater value for soil and water conservation were it not that it has been entirely sacrificed to grazing and browsing. It is only after grazing has been brought under control by one or other of the means discussed in Chapter VIII, that such areas can be made more productive and can be classified according to that use which is of major importance, namely, protection (for water catchment duty), fuel or timber production, shelterbelts (to protect village lands), grass, rotational grazing, or a combination of any of these.

Demarcated Forest Settlements.

5·9. Government's intention when carrying out forest settlements some 60 to 80 years ago was to ensure that the local inhabitants would not be victimized by a wholesale exploitation of the forest surrounding their homes. When those settlements were made the villagers were few and scattered and the civil officers who made them could not be expected

to visualize the enormous increase in the population, both human and animal, which has occurred in the subsequent long interval of peace and protection. The result is that, for want of some clear indication of the numerical limits of the grazing privileges allowed, the forests are now overrun with vast herds of hungry and economically worthless animals whose control is impossible because their unfettered movement is safeguarded by these old privileges which the Forest Department is legally bound to provide for.

5·10. The legal definition of a *right of user* lays down that the privilege must sustain itself, i.e., that neither the owner nor the right-holder may use the land or the right so heavily that its future produce is diminished. Legally speaking, therefore, rights which are being exercised so freely as to exterminate the forest, should be made null and void, or should be revised so that they become less destructive and more permanent. This point of view has never been enforced in any ruling, and meanwhile large areas of demarcated forest are deteriorating lamentably. The total area of demarcated forest in the Punjab and North-West Frontier Province is 5,466 square miles, but out of this only 562 square miles are closed to all animals (in order to ensure the reproduction of valuable tree crops) and only 1,100 square miles are closed to browsers.

Rights of Users Misused.

5·11. The same criticism of the legal position holds good in connection with the lopping of tree leaves for fodder and of branches for litter. The trees most commonly lopped for fodder (see paragraph 9·4) are the oaks (*ban*, etc.) in the hills and *kao* (*Olea cuspidata*) in the outer foothills, while those lopped for litter include several commercially valuable conifers whose timber production is seriously interfered with. Lopping is in many forests legally permissible under the settlement ; there again the concession when it was originally allowed must have been a very small one but has now grown to a serious menace. In the case of the Murree oak forests and the mixed broadleaf forests of the Galies it has already brought about the complete extermination of these valuable species from whole forest blocks, leaving behind a depressing ruin which is now practically worthless either for water conservation or any forest produce, while its fodder value also is spoilt. Bitter experience has shown that no system of rules attempting the partial restriction or control of lopping by height limit is feasible in face of local economic pressure. The only way to save the fodder trees is a rigid enforcement of rotational lopping.

Excessive Tree Lopping.

Note—The lopping of oak throughout Kangra but particularly in the Gadderan tract as increased to an alarming extent since this book was written.

CHAPTER VI.—The Menace of Erosion and Drought

General increase in Drought Damage and its causes.

6·1. Frequent references are to be found in Revenue-Settlement revisions in both the Punjab and North-West Frontier Province (e.g., Mansehra Tahsil) which indicate very clearly that there is a progressive desiccation being experienced in cultivated lands. This deterioration is widely distributed throughout all the *barani* lands (bearing rain-fed crops), but naturally one would not expect it to be noticeable in the larger canal colonies. Even in these, however, the shortage of winter water for *rabi* crops is a common complaint, except in those relatively small areas which are actually suffering from waterlogging through a cumulative rise in the subsoil water-table. Our chief concern is with the rest of the farm tracts which are not irrigated except from small local streams or by wells. In these there is a tendency towards aridity which is proved by the dwindling winter water supplies from local streams and which is too great to be explained by minor changes in the climatic cycle. The increase is undoubtedly due to the growing inability of the soil to retain whatever moisture falls upon it, because through erosion the wasted top-soil is being replaced by the less absorptive clay which usually forms the subsoil. This cumulative failure of the soil itself to soak up and retain rain-water is of far more importance in causing drought than any minor changes in the actual amount of rainfall, though its importance has not yet been grasped by either zamindars or officials. Its effect is most evident in *barani* lands which are directly dependent upon the storage of a part of the rain which falls directly upon them, but indirectly, though no less surely, it must affect well levels for *chahi* irrigation and also the winter level of small streams which depend upon springs and underground seepage of water for their winter flow. This failure to absorb and pass on a share of the surface run-off should be felt least of all by the larger rivers which depend upon the great snow-fields and glaciers for most of their supplies, so that the big canal colonies are least likely to be affected, but even in these big rivers *the winter flow* depends to a great extent upon the subsoil drainage which reaches their foothill tributaries, and so they too are bound to deteriorate in their winter flow owing to the widespread desiccation in the foothills.

6·2. The direct effect of forests in *inducing rain to fall* has been somewhat exaggerated in the past and should not be unduly emphasized. Modern scientific opinion now holds that general and large-scale moisture movements over the earth's surface, such as our North Indian monsoon, are scarcely affected by the presence or absence of forests, but that local storms caused by minor instabilities in atmospheric pressure may be influenced to a much greater extent by forests. Most of our winter rains are of this latter description and any influence exerted by forests should therefore be felt in the non-monsoon rainfall rather than in the monsoon itself. Increasing desiccation is putting a premium upon the value of winter rains so that the effect of forests in inducing rain to fall is still important though not as great as was formerly imagined. The really important part played by forests is *in making better use* of the actual rainfall by reducing floods and spreading the run-off over a longer period.

Effect of Forests on Rainfall.

6·3. In Hoshiarpur and parts of Ambala there has been a marked deterioration in the available water supplies during the last 50 years. The rainfall of Hoshiarpur town averaged 36″ in the period 1870—1900 but this has dropped to 30″ for the subsequent period 1901—1931. A decrease in the total rainfall has apparently taken place on and around the Siwaliks during this period which may possibly be explained by a cycle of climatic changes ; meteorologists state that these cycles of deficient rainfall tend to occur in periods of 11 and 33 years and are due to changes in sun-spot activity on the sun's surface. The decrease in the Siwalik rainfall must also be to some extent connected with the destruction of forest cover which has been allowed in the Siwalik foothills. Immediately across the Jumna in Saharanpur the forest cover has been properly protected and no deterioration of water supplies has been experienced. The worst damage done in Hoshiarpur and Ambala is due to the failure of the plant cover to preserve the country from alternate floods and droughts. The most serious part of the present situation is not that the rain has decreased, but that the foothills are now so badly denuded that they are incapable of storing more than a minute fraction of the rain which falls upon them.

Local Desiccation.

6·4. It is of very vital importance that both cultivators and officials should be taught the real truth of this increasing desiccation. The danger for the future lies not so much in actual decrease of rainfall as in failure of the catchment areas in the foothills to trap and store a reasonable share of whatever rain or snow falls. This failure is the effect of erosion in its various stages, and as it affects both cultivated and uncultivated land, but in different ways, a detailed account of the processes of erosion is given below.

Cumulative effects of erosion in causing drought conditions.

6·5. The importance for agriculture of the topsoil has already been pointed out in paragraph 2·1 and the need for conserving this portion of the soil is again emphasized, for this point must be borne in mind when studying the paragraphs which follow. In ploughed fields of course the plant cover provided originally by nature has been removed, but in grazing grounds some of this is still being used, while under forest it has been preserved to a much greater extent. Wherever destruction or deterioration of the plant cover has taken place, changes in the soil texture also occur. A fully preserved forest or grass-land soil shows in its profile, or vertically cut exposed face, a very gradual transition through many grades down to the parent rock below, but those changes are all so gradual that there is no sudden break anywhere in the profile. (Fig. 2, page 13.) Such soil with its vegetation is a living entity carefully built up through thousands of years and capable of diverting a large percentage of rain down into the subsoil and the rocks below. Whenever this balance between precipitation and cover is upset, either by forest fires, heavy grazing or clearing for cultivation, less rain is absorbed and the increased surface flow is capable of accelerating the natural process of erosion. A certain small amount of erosion takes place in all circumstances, but this geological erosion is very slow indeed compared with the accelerated erosion which takes place once the plant cover has been interfered with.

Vital Importance of Plant Cover.

6·6. (*a*) *Sheet washing.*—The first effect of releasing a larger surface flow is for soil particles to be swept along and carried over the surface of the ground, for even when the ground is practically level, rain-water gains some momentum while running off a bare surface. The effect of this is that the natural pores or spaces in the soil become clogged up

Types of Erosion Damage.

with this sediment which is being washed along. This immemediately interferes with further seepage or percolation by the soil. Dr. W. C. Lowdermilk, one of the pioneers of the soil conservation movement in the United States, proved the importance of this phase of erosion phenomena by an interesting experiment(4). By introducing 2 per cent of sediment into water and making this mixture percolate through a soil surface, the rate of percolation fell off 90 per cent in six hours as compared with clear water ; and reverting to the use of clear water did not accelerate it afresh. This plugging acts as if a paste were spread over the ground surface, sealing up pores and spaces. Thus silt-laden water has a disastrous effect in reducing the amount of seepage, so that more water is forced into the paths of surface drainage. The fresh light thrown on the process of soil erosion by Dr. Lowdermilk's experiments has helped us to understand much more clearly just exactly what happens when soil is first washed off from any soil surface.

Finger Gullies.

6·7. The next thing that happens further down the slope is a sort of sand-papering action, because silt-laden water rubs away the floor and sides of the channels in which it flows. In an open field these channels form a fine network of " finger-gullies " only a fraction of an inch deep, and in each of these, fresh soil is abraded and swept away. The effect over the whole field is to carry away a thin skin of soil from the whole surface. When this has occurred on a field, ploughing immediately hides all traces of this net-work of finger gullies, so that the process is not so commonly recognized as it ought to be. When it occurs on grazing ground, it is checked to some extent by the mat of the plant cover but on the other hand nothing is done to fill the finger gullies up, and so they go on cutting deeper.

Loss of Valuable Chemicals.

6·8. In addition to robbing the top soil by the mechanical removal of soil particles, accelerated erosion has been proved to remove a relatively greater amount of soluble chemicals which are vital to the plant—in other words it robs the still undisturbed soil of its best chemical properties long before it actually washes it away. This has been proved repeatedly by growing wheat and other plants in pots containing soil from eroded and uneroded spots from the same field ; the plants in the eroded soil are always much poorer. The soil which is left behind after erosion is also

poorer in the micro-organisms which are so important for the proper development and functions of roots (5).

6·9. (*b*) *Gullying*—When these finger gullies are allowed to deepen, the next stage of deeper gullies comes on, and clefts are formed which bite down through the top-soil to the sub-soil. This may be more easily eroded than the top-soil, and if it is, the surface is very soon cut up into blocks separated from each other by ever deepening gullies. Not only is cultivation rendered difficult by these obstacles ; the ground is artificially drained to a greater extent than formerly, so that the blocks of soil that are left are much drier and less productive. Similarly in grazing land or in forest where deep gullies are allowed to form, the previous moisture balance is upset and the existing plants can no longer remain healthy because their soil moisture ration has been reduced. In the case of deep rooting trees such as oaks, the old crop will persist for some time, but the regeneration of young trees to take their place will be prevented by lack of moisture, and so the crop inevitably dies out.

Phenomenal Storms.

6·10. Deep gullies are often formed as a result of one phenomenal storm of sustained and heavy downpour falling on land which has been unduly exposed by misuse in the past. Once these gullies have been cut out, the ground can never return to its former productive capacity because the whole drainage regime has been changed. It is not the average rainfall that does most damage, but a single infrequent but exceedingly heavy storm which by cutting out fresh gullies starts a new cycle of erosion. Many local instances of this could be quoted for September, 1924, in the Eastern Punjab hills and for August, 1929, in the North-West Frontier Province.

6·11. (*c*) *Bank Erosion and Sand Deposition by Torrents*—A common source of loss in the more gently sloping lands of the Punjab is through the behaviour of torrents after they have debouched from their hill catchment areas. In this part of their courses these hill streams when in flood have accumulated very heavy loads of silt and sand which they use for further destruction. On the one hand they can undermine and cut away large sections of bank wherever high banks of unconsolidated soil or gravel exist along their course ; these banks often carry fields and villages which are thus destroyed. More generally, on the other hand, torrents dump their excess load of coarse and infertile sand on ground which is far beyond their ordinary bed, and in this way smother and bury

valuable lands so deep in sand that they cannot be further used. Numerous instances of this type of damage can be seen all along the main foothills from Nalagarh State east of Ambala to the trans-Indus districts in the west, but possibly the most spectacular instances are the Sauj and Bunha torrents which rise in the north face of the Jhelum Salt Range. In Jhelum district alone some 50,000 acres of cultivable land have been lost in the last 36 years, thus averaging 2½ square miles a year of land destroyed. The various methods of controlling erosion in fields and grazing lands are dealt with in Chapters VII and VIII and stream training technique in paragraph 9·15.

6·12. (*d*) *Wind erosion*—The removal of soil particles by wind is a less noticeable phenomenon than gullying by water erosion but it is nevertheless of considerable importance in some of the flatter lands of the province. Wind-blown sand tends to form a special land-scape of long flat stretches broken by hummocks with bush growth on top of them and wind channels hollowed out all round these miniature hills. Where level plains of grass-land have been too heavily grazed the grass tends to disappear and be replaced by deep-rooted bushes such as *chitti bui* (*Otostegia limbata*) round which the wind gradually builds up sand dunes around Campbellpur. Such dunes menace neighbouring fields and pastures because any severe storm may drive the sand on to them and bury them.

Control of Wind rosion.

6·13. The same principle holds for wind erosion as for water erosion. Sand dunes form only when the natural plant cover has been thinned out or destroyed through misuse and the obvious way to prevent sand blowing is to keep plenty of wind-breaks and shelter-belts of tall grasses, bushes and tree growth, prevent cattle from destroying the natural grass-lands, and keep a good proportion of field crops in dense strips at right angles to the prevailing wind. This type of work is very badly needed throughout Rohtak, Hissar, Sirsa, Gurgaon, Karnal, Ferozepore, Faridkot, Bikanir, Bahawalpur, the unirrigated parts of Montgomery, Multan and Muzaffargarh ; the whole of the Sind Sagar Doab, and Dera Ghazi Khan.

6·14 *Summary of Soil Erosion Losses—*

Stage.	*Effect.*
Soil is exposed by destruction of plant cover.	Rain runs off more quickly.
Surface soil begins to wash away.	Natural pores of soil become clogged up and this stops water soaking in. Valuable chemicals are washed out of the top layer of soil.
Small gullies cut a network on surface.	Top layer of soil is destroyed and removed. A heavy load of fine silt is carried down the streams.
Deeper gullies attack subsoil.	Whole of soil is drained dry so that plants can no longer live there. Streams become heavily loaded with coarser soil particles.
Streams cut their own beds deeper.	Great loads of silt and sand are dumped in the lower reaches of the river bed so that the river is forced to change its course or flood the surrounding country.

CHAPTER VII.—FARM EROSION AND ITS CONTROL.

Erosion in Farm Crops.

7·1. The need for preserving the natural plant cover has been emphasized, but this obviously cannot apply in the case of cereal and other annual crops whose cultivation entails ploughing and exposure of the soil for at least part of each year. The alternative is to plan each field or group of fields so that by every possible means the run-off is controlled and delayed, the percentage of seepage is increased, and the amount of soil carried away is reduced to the absolute minimum. The various means by which this can be achieved have already been defined in paragraph 2·5, but are discussed below. They include keeping the soil in an absorbtive condition as well as the direct checking of run-off by earth-work barriers and dense masses of plants. No single item is a complete cure and better farming lies in the judicious use of as many as possible.

Effect of Slope

7·2. The effect of steepness of slope is difficult to value mathematically, because the effect of slope in inducing run-off and erosion is mixed up with many other factors, for instance a sandy soil with coarse but loose gritty grains will erode much more heavily from a steep slope than from a gentle one, whereas a compact clay will erode almost as much from a gentle slope as a steep one. Aspect also is important, e.g., the same soil will erode less from a cool north slope than from a similar slope facing south owing to its better protection from sun and frost. Speaking generally, however, it is safe to say that soil loss increases appreciably with increased steepness of slope and this explains why so much emphasis has been placed in previous chapters on the need for better terracing.

Terracing of Steep Slopes not Economic.

7·3. For gentle slopes terracing of soil or turf or stone is fairly simple and within the powers of the poorest zamindars to build and maintain. The steeper the slope, however, the heavier the task of building terraces becomes until a slope is reached for which properly built terracing is beyond his capacity of labour and funds. No very reliable local figures are yet available from direct experiment but from experience arbitrary figures have been suggested in paragraph 5·4 for fixing a maximum above which cultivation should be discouraged.

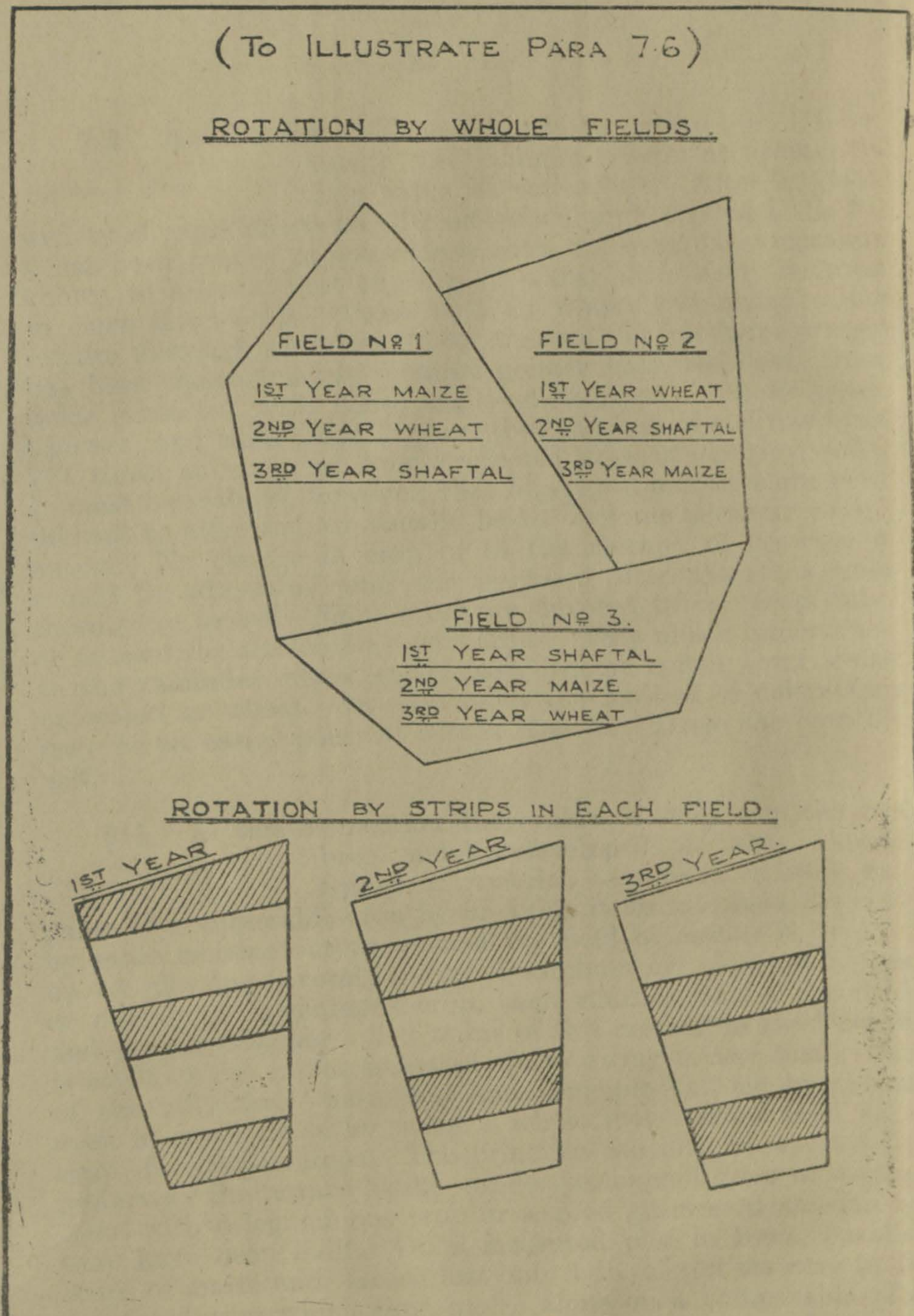
7·4. An attempt has been made in paragraph 2·4 to classify the common crops according to their value as soil-savers. After a great variety of experiments on all kinds of soil and crops in U. S. A., it has been proved in accordance with the most exact methods known to science, that the loss of water from fields devoted to clean-tilled crops (those such as wheat and maize which require thorough ploughing to obtain bare oil for their sowings) has been approximately 7 times greater than the loss from fields protected with dense unploughed crops, such as grass, legumes, and trees ; and further, that the loss of soil has been 174 times as much as from protected areas of identical soils. It must be realized, however, that local crop practices are very difficult to alter and are usually based on some perfectly sound reason. No change in crop or in the method of growing it should be advocated until the proposed alternative has been thoroughly tested. Many areas are devoted to one crop only, or at least the alternatives used are of very minor importance to the zamindar whose entire cash income comes from maize or cotton or wheat. In such cases the method of cultivation may be an easier point of attack than to change the crop itself.

Choice of Crop.

7·5. In this connection the value of *strip cropping* has been much developed in the United States of America to reduce a wide expanse of a vulnerable crop by breaking it up into belts divided by more resistant crops, e.g., a big field of cotton is broken up by planting several strips of sorghum or elephant grass or any dense leguminous crop, each running across the field and *along the contour*. The value of this method in the Punjab is small except in the irrigated tracts owing to the small size of the individual field, but the principle can be employed even in small fields by using a whole long narrow field as a strip for denser crops. The principle can also be applied by preserving the terrace banks under permanent grass or sowing them with a leguminous crop or a good grass seed as soon as they have been built. On a measured plot in Iowa, parallel strips of maize and lucern lost only 1 lb. of soil per acre in 18 months during which time maize alone on a comparable plot lost 9 tons of soil per acre (4). The steeper the slope the larger is the percentage of the field to be devoted to strip crops, but for average cultivated slopes one-quarter of the total area should be quite sufficient, and even one-tenth would be of some service.

Strip Cropping.

Fig. 4


(To Illustrate Para 7·6)
ROTATION BY WHOLE FIELDS.
FIELD No 1
1ST YEAR MAIZE
2ND YEAR WHEAT
3RD YEAR SHAFTAL
FIELD No 2
1ST YEAR WHEAT
2ND YEAR SHAFTAL
3RD YEAR MAIZE
FIELD No 3.
1ST YEAR SHAFTAL
2ND YEAR MAIZE
3RD YEAR WHEAT
ROTATION BY STRIPS IN EACH FIELD.
1ST YEAR
2ND YEAR
3RD YEAR.

7·6. Practically all farming has some form of rotation of crops as its basis and all farmers realize the need for changing the crops grown on one piece of ground. An exception is the irrigated rice crop which is carried on indefinitely year after year, owing chiefly to the special watering which is unsuitable for any other crop ; this continued cultivation can only be done with very heavy manuring, and where erosion loss is negligible. Where a highly soil-exhausting crop such as maize or potato or tobacco is popular, every effort should be made to obtain a better balance by introducing less erosive crops such as leguminous fodders or wheat into the rotation. Jowar is satisfactory in checking erosion but is regarded by the Agriculture Department as exhausting to the soil in its use of chemicals. Rotation can be done either by whole fields or by strips, e.g. if the rotation is wheat, then shaftal, then maize, either the whole field is changed in that order ; or else for big fields, strips of 1/3rd of the total area are sown with each crop, next year the shaftal is sown where the wheat was and the third year the maize goes there. (Fig. 4).

Crop Rotations.

7·7. During periods of rainfall of exceptionally high intensity, even fully levelled fields cannot completely prevent all surface run-off, and the provision of additional and secondary measures of defence against soil erosion are necessary to limit and control the movement of all surplus run-off water. This is the proper function of drains, silt pits, platforms and terraces. In the past it was customary to lead this water off the land, or to allow it to run off by the easiest and quickest possible route, no account being taken of the soil which went with it. Such methods are now regarded as obsolete. The modern conception of drains is that they should act, first in aiding absorption of rain-water falling on the land ; second the removal of surplus water can be controlled, and third collecting, for return to the land, any silt which has been eroded and carried into them. For these purposes the construction of drains should be guided by scientific principles, and their size and frequency be determined by the maximum amount of run-off water they may be required to hold up. To this end it is desirable to establish contour drains, contour terraces and contour platforms in newly opened land where crops or orchards of fruit or other open-grown trees are being put out for the first time.

Field Drains.

7·8. The provision of locks and steps in drains is a distinct improvement over the ordinary free flow type of drain, and the division of lengths of the drain into flat or horizontal sections, silt-pitted at their downstream ends and divided by bunds, is a further improvement. Drains with each section cut with a reverse slope provide perhaps the best means of flow control. Main down-drains, where they exist, or their use cannot be avoided, should be altered and improved or constructed so as to reduce the rate of flow of the water they carry. Better still, what is often a rushing torrent may be reduced to a series of gentle cascades by the adoption and construction of the step and water-cushion system. (Fig. 5.) In all cases where main down-drains are employed for the removal of water it is important that they should be properly sited in natural folds on the concave faces of the hill [7]. There is almost unlimited scope for small simple stone dams being built in the minor torrent beds in the foothills where sufficient water to irrigate 2 to 4 acres of *kharif* crop could be caught and held from the flood water which now goes to waste.

Drainage Devices.

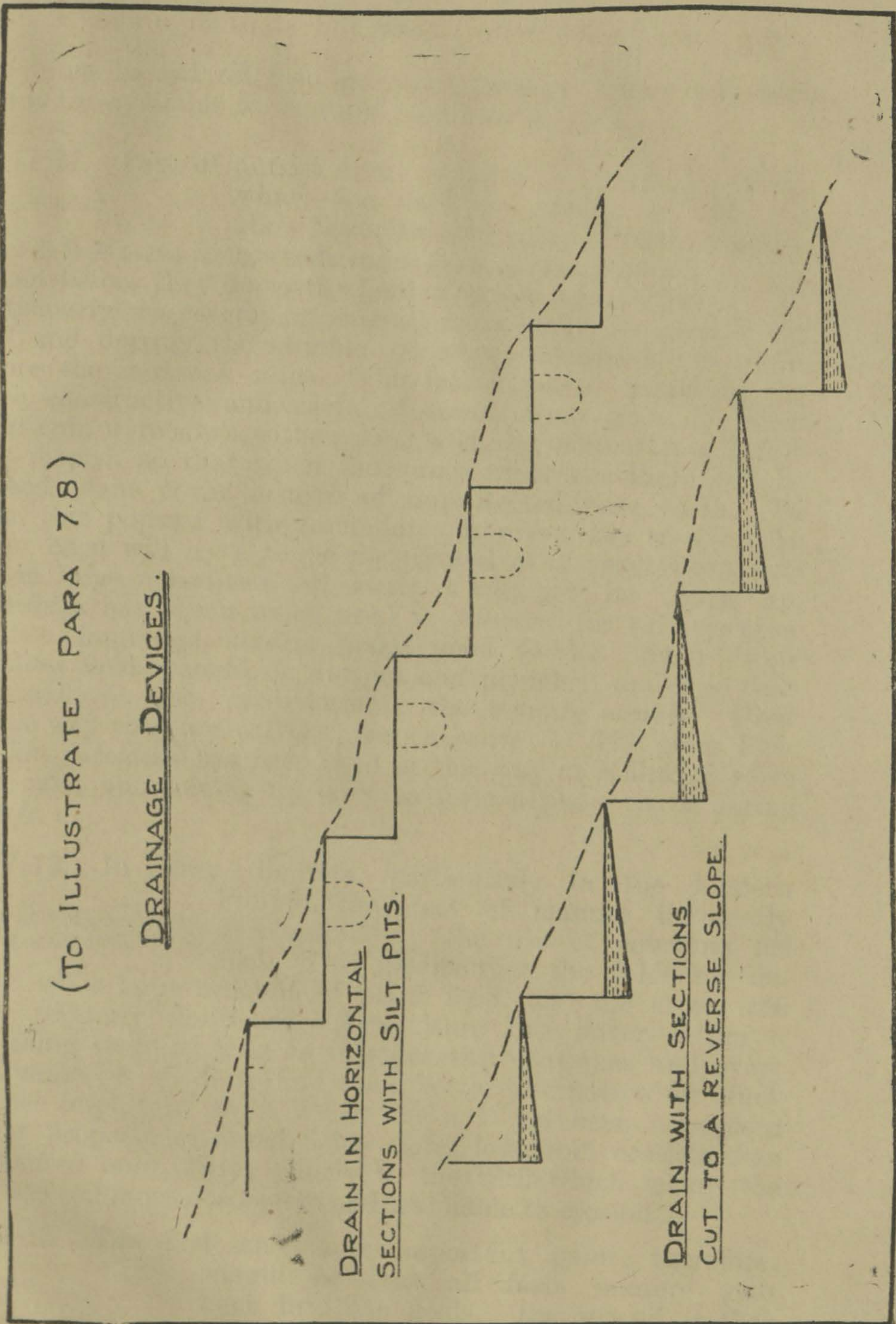
7·9. Silt-pits are a useful form of protection, but by themselves they are not the most efficient. If employed alone in alternate contour rows, or at intervals in the beds of drains, they have a restricted value. Their value is limited by their size and frequency, and by the quantity of water they are required to hold up. Their effective capacity for the retention of water and the collection of silt is restricted to the pits themselves, and once they are full of water (or silt) they become valueless because run-off water flows unhindered over them. The effectiveness of silt-pits is dependent upon the percentage of the rainfall they can hold up and the rapidity with which the water they hold up can be absorbed by the surrounding soil.

Silt-pits

7·10. Contour platforms are considered to be a progressive method when opening new clearings or replanting old areas. In most efficient types the platforms are neither level nor continuous ; they should have a reverse slope, i.e., the platform slopes backwards into the hillside, the inner edge being at least a foot below the outer ; also they should be partitioned off into sections by leaving small buttresses at intervals to limit the unnecessary lateral movement of water along the platforms. The drainage from road surface and cross-country tracks

Contour Platforms.

Fig. 5


(To Illustrate Para 7.8)
Drainage Devices.
Drain in Horizontal Sections with Silt Pits.
Drain with Sections Cut to a Reverse Slope.

can often be led off into properly terraced fields, and thus add to the available water supply for *barani* lands.

7·11. Part of almost every rotation is a fallow during which the field lies empty in order to allow the soil a rest from constant cropping.

Bare Fallow.

First it lies bare, then weeds come in on it and gradually cover it, but before they do so the field may lose a great deal of soil, particularly where grazing animals are allowed to trample the field and destroy the stubble, or where the stubble is burnt before the monsoon rains. The fallow period would be far more constructive and useful if some cheap grass or other plant crop were sown, either along with the main crop or before it is reaped, so that when the monsoon breaks there will be a good plant cover instead of unprotected bare earth. To make this popular with zamindars, however, the seed of the fallow crop will have to be distributed at a very cheap rate and in large quantities, otherwise it will not be taken up. Lespedeza has been much used in America for this purpose because improved strains make good fodder. Such crops in fallow fields should be dug up and ploughed under so that they will rot and contribute to the manure supply. Used in this way they are called "green manure ". The grass *Pennisetum flaccidum* has been used in this way at Muktesar sown with oats, but coming up later to form a plant cover during *kharif*.

7·12. In many districts, particularly in the Eastern Punjab, the lack of manure is greatly emphasized by the use of cowdung for fuel. This means that the fields are deprived of a large amount of plant food, and the crops are never properly nourished. Agriculture can never be in a flourishing state as long as this practice continues and every effort must be made to find some better alternative for fuel. Another important point which has not yet been recognised is that properly manured fields suffer less from erosion than unmanured ones, owing chiefly to the tilth which makes the manured soil more absorptive and less liable to erosion.

Lack of Manure and Burning of Cowdung.

7·13. The first and most important point, therefore, should be that all farm manure goes back into the fields, the second is that this manure should be economically used. This can best be secured by composting it in shallow pits or heaps along with all vegetable rubbish, weedings from fields and gardens

Compost.

and litter from cowsheds, so that the vegetable material is thoroughly rotted down by repeated turning over and keeping damp. In this way the available farmyard manure can be made to produce about four times its own bulk, and the only cost entailed is manual labour. An alternative way is to put all the vegetable rubbish, stalks, weedings, etc., under the feet of the cattle in the cowshed, collecting it when it is sodden, and changing the litter frequently so as to get as much as possible soaked with urine. This must then be stacked properly and prevented from drying up, because dryness stops the bacteria from working.

In the absence of any other fuel supply than cowdung an obvious line of attack is to provide plantations for wood fuel. This is dealt with later in paragraphs 9·11 to 9·14.

7·14. Hedges. The use of dry thorn branches for fencing fields against livestock is a most wasteful and uneconomic custom which should be stopped. The cut branches are only serviceable for less than a year and have to be replaced frequently, so that the practice entails a constant drain upon the neighbouring scrub jungle and contributes materially to local disforestation. After a few months these thorn fences are easily broken down, allowing herds to damage the field crops. The space occupied by such hedges is unproductive of grass or any other commodity, and they make no contribution towards soil or water conservation. A much sounder plan is to have field boundaries planted with living plants such as *keora* (*Agave*), *taur* (*Euphorbia*) *chitta taur* or *gangichu* (*Opuntia*), or other thorny bushes which will form a permanent protective hedge and also help in checking run-off and soil losses from fields. *Keora* is much the best because it will also yield a fibre from the leaves, while *taur* is of no commercial value and is subject to occasional insect attacks which kill it out entirely over large areas. *Taur*, however, is more easily propagated because it will root from any short branches or leaves stuck in the ground. *Keora* is best grown by transplanting the small complete plants which spring up as root-suckers from the roots of established older plants, though it can also be grown from the curious *bulbils* or miniature rooted plants which are produced instead of seed on the tall flowering poles of the *keora*.

7·15. Agave. There are many varieties of the *keora* in the Punjab, e.g., *Agave wightii* with very short stiff prickly leaves ; *A. cantala* with longer

drooping leaves ; *A. americana* with variegated leaves, margins yellow : *A. veracruz*, with a broad bluish-green leaf ; the true sisal hemp, *Agave sisalana*, deep green and with only a terminal spine ; the Mauritius hemp, *Furcraea gigantea*, bright green and only a small terminal prickle, is not recommended. A desirable type giving both a good hedge and a useful fibre should be obtained for planting if not available locally.

7·16. Transplanting of *keora* and *taur* should be done on slightly raised earth banks or bunds. These banks should be built along the contour when they are to form divisions or boundaries of fields, but roadside banks must naturally follow the road alignment whether level or not. In this case long lengths of trench should be broken up by cross-dams so as to prevent scouring and to form a series of small tanks. Living hedges of either species require very little attention, but old hedges which are so dense that they straggle on to fields should be thinned out and the spare plants replanted where the hedge is too thin. Other useful hedge plants are *phulai* (*Acacia modesta*), mesquite or *walayati jand* (*Prosopis glandulosa* and *juliflora*) and *kabuli kikar* (*Acacia farnesiana*). These should be sown thickly along the edge of a trench and later cut back to encourage a dense coppice growth of sprouts. A hedge plant which deserves wider notice in the drier western districts is the edible Spanish cactus introduced in Campbellpur by Mr. A. MacLeod and since distributed locally ; its fruit yields a useful food.

Alignment of Hedges.

7·17. The most primitive early farming was done by cutting down a piece of forest, burning it and sowing wheat or maize on the ashes. As long as there was plenty of forest, fresh patches could always be taken up, but as the forest disappeared the custom stopped. It is still in use wherever the population is small and the forest growth is dense, although under most forest settlements in the Punjab hills it is prohibited in reserved forests. In the lower foothills where *sanatha* (*Dodonea viscosa*) and chir pine come up fairly quickly on bare ground, the same ground is reploughed at long intervals of 5 up to 20 years, so that this is half way between shifting cultivation and a long fallow, but as a rule heavy grazing prevents the forest growth from coming in again when cultivation is given up. Much forest growth is still being destroyed each year (e.g., the higher blue pine and fir woods of the Simla Hill States, the

Shifting Cultivation.

oak woods of Kangra district and the chil, oak, and broadleaf forests of Hazara).

As a rule there is little or no attempt to build terraces so that the loss of soil from potato and buckwheat patches is enormous, probably amounting to as much as 200 tons per acre per annum or one inch in depth of topsoil. The chief offenders are the itinerant grazier tribes such as Gujars and Gaddis, whose standard of cultivation is very poor indeed, but pressure of population has also led to a recent increase of this type of cropping by ordinary residents in the higher hills. In the foothills *kamins* and menials are largely responsible.

Control of Bad Cultivation.

7·18. The practice wherever found ought to be checked and controlled by more stringent local rules and by more careful inspection of those backward tracts by forest officers and others. In many areas insufficient attention has been paid to the recommendations of the forest officers, who have not been able to enforce any control over land which falls outside their own forest boundaries. In the case of really important catchment areas a recommendation will be found in Chapter X that such cultivation should not only be forbidden in future but that blocks of outlying and poorly terraced fields on the edge of village lands should be acquired by Government and reforested. Where shifting cultivation is abandoned, leaving the fields unused, every effort should be made to protect them from grazing and establish a thick plant cover quickly even when it is not possible to plant desirable tree species.

Advantages of Consolidation.

7·19. Many of the faults of bad farming are due to the scattering of small fields of one man's holding all over the village, and could be most effectively handled under a programme of consolidation of holdings. Not only will the cultivator's time and energy be conserved by having his plough land all in a few large blocks, but the building of *watts* will be greatly simplified, particularly if the new fields are given a maximum length along the contour and a minimum width up and down the hill. Where the waste land has been broken up into small and scattered holdings consolidation of the waste will also encourage a more intelligent use of their

uncultivated ground by individuals. Consolidation of holdings is particularly valuable where widespread and deep gullies have broken through the old pattern of field lay-out and drastic measures are needed to stop the rot. The average foothill village requires a comprehensive co-operative society which can handle consolidation of holdings, division of *shamlat*, *watt-bandi* and *cho* reclamation wherever these various activities are of benefit to the members.

CHAPTER VIII—GRAZING-LAND CONTROL AND IMPROVEMENT.

8·1. *Effects of Overgrazing.* The human population of India is increasing at the rate of about three millions per annum. Much of this increase is occurring in the tracts where nature in the first place provided easy conditions for human settlement, namely, a rainfall not too heavy for the ordinary farm crops, and natural grass-lands in which cattle thrive and remain healthy. Within the heavy rainfall areas further east, the re-growth of dense tropical jungle and conditions inimical for livestock have discouraged dense settlement. Therefore, much of the weight of this increasing population is falling upon what is botanically a *tension belt* where grass-land can persist only under reasonable treatment, and, if once destroyed, cannot reinstate itself as easily as it can under a slightly heavier or better distributed rainfall. Hence over very large tracts of Northern India natural grass-lands have already disappeared and village livestock are dependent upon bush and tree growth for their day-to-day existence.(6) In most other countries livestock are maintained on a ration of grass, and the bush growth which occurs in the grazing grounds is looked upon as a natural reserve which should be used only in times of famine or scarcity and not as part of the ordinary daily ration for the village herd.

8·2. *Cusecs of Deterioration.* An efficient forage plant must be able to recover rapidly after being grazed, and grasses and shrubs vary greatly in this respect. Many plants which provide a good food at certain times of the year are not at all efficient in this sense ; but any plant, no matter how virile, will succumb sooner or later to prolonged continuous biting by live-stock, and it is only on some basis of periodic resting that a grazing ground can remain productive. The chief causes of deterioration in village grazing areas are :—

(*i*) Premature grazing when vegetative growth is just beginning in the spring or the break of monsoon rains.

(*ii*) Continuous grazing without any respite.

(*iii*) Over-grazing by trying to feed too many animals of too few acres.

(*iv*) Trampling and puddling the soil when it is soaked.

(*v*) Using the wrong kind of stock or the wrong mixture of classes.

(*vi*) Bad distribution through concentration of stock at watering points, night bedding grounds, freshly burnt areas, or on a succulent fringe.

'Over-grazing' has come to be used as a general term for all these forms of abuse, though in a great many cases proper control on a scientific basis will provide for a larger head of stock, and certainly a larger eventual revenue, than can be got from land where any one of these faults is found.

Local Customs.

8·3. Grazing on Punjab forest land has really only been controlled where it has interfered with the management or regeneration of the forest tree crop. Elsewhere in demarcated forest, control has usually been rendered difficult or impossible by the grazing allowed under the Forest Settlement, as indicated in paragraphs 5·9 to 5·11. In other types of land open to grazing, e.g., undemarcated or unclassed forests under the Civil department, unclassified forest village lands (*dakha darakhtan* and *dakha rakh*) and grazing lands proper (*dakha charagah*), little or no attempt at control has been made. There is frequently a local custom of closure to give some respite during the rains when grazing is fairly plentiful immediately around the village, but this, although a step in the right direction, is not sufficient to prevent further deterioration, because it does not prevent over-grazing by sheer weight of numbers during the rest of the year, nor does it allow enough time for the grass and shrubs to seed and regenerate themselves.

Grazing Incidence.

8·4. No accurate figures are available for Punjab conditions to show the number of acres per animal which will provide steady grazing without allowing any deterioration either in the animal itself or in the condition of the grazing ground. No Punjab grazing ground is equally productive throughout the year, and most types are entirely non-productive during the hot dry months of May and June. If stall feeding or a ration of prepared fodder such as stored grass or wheat straw or silage were fed to the herd during this bad season, the animals would keep in better condition and the grazing grounds would also be in a better condition to recover from the drought.

Local Concentration.

8·5. Figures of average incidence for large areas do not show us the true situation. For instance, 12,000 acres of forest may have 4,000 animals grazing in it, making an incidence of 3 acres per head, but if the entire livestock concentrates round one watering point and the shady forest around this point, this part of the forest will be seriously over-grazed though the rest is hardly used at all. In America salt blocks are put out in

ungrazed areas to encourage the animals to go further into them and use them more ; this has also proved useful in the Bombay Deccan.

8·6. Hazara Figures. The following figures of grazing incidence have been used in the Hazara Galies forest working plan, and are quoted as they give a good indication of the variety of conditions found in a single forest division covering only a part of one district :—

Grazing Incidence in different kinds of forest

Kail, dense, 25 acres per cow ..	For eight months, May to December ; remaining four months are under snow.
Kail, open, 20 ,, ,, ,, ..	
Fir, 15 acres per cow .. (includes yew, which is heavily lopped here though not in other districts).	
Broadleaf, 10 acres per cow ..	
Subalpine grass meadows : 3 acres per cow, 5 acres per buffalo.	

Lopping and Weed-cutting

Fir and broadleaf mixture, 5 acres per buffalo.	Season is July—September for weeds, May—October for tree lopping, say, six months' period for all cutting.
Broadleaf trees, 3 acres per buffalo ..	
Broadleaf bushes (mostly unpalatable Viburnum), 12 acres per buffalo.	
Plantation areas (weed cutting only) 5 acres per buffalo.	

8·7. Reduction of Livestock. The primitive idea that livestock represents wealth is responsible for the keeping of far larger herds of cattle than the milk and plough-cattle requirements justify. Figures for Mandi State, for instance, show a total of 104,000 male cattle for a total of 26,000 ploughs and 102,000 milk cows. Such animals are really a heavy burden, because they destroy the pastures and give nothing in return. Possibly the best justification for large herds is that they constitute the only source of manure for the fields, and this is a point which requires careful thought in preparing any scheme for reducing surplus herds. In the absence of forests, cowdung is the only fuel supply as well as the only manure. With a Hindu population any attempt to slaughter or otherwise dispose of surplus stock is likely to be resented, so that summary reduction is not a feasible proposition. The following alternative methods of approach

should all be considered and applied as far as possible :—

(1) Establish demonstration farms and fenced plots which will give practical illustrations of the benefits of lighter grazing.

(2) Educate the rural population in the simpler essentials of animal husbandry.

(3) Extend the use of bloodless castration, in which the local forest guards and stockmen can easily be trained ; and the separate herding of bulls, rams and goat bucks.

(4) Create village fuel plantations to provide a substitute for cowdung as fuel.

(5) Encourage the use of green manure crops (ploughing down leguminous and other herbaceous crops to increase the organic content of the soil in cultivation (see paragraph 7·11).

(6) Develop the use of a compost manure in which all vegetable and organic waste matter is made use of (see paragraph 7·13).

(7) Develop the use of the silage pit to produce cheap supplementary feed when grazing is poor. All other manufactured feed is much too dear to be a feasible proposition, but by saving all available green crops, ensilage is a valuable cheap feed.

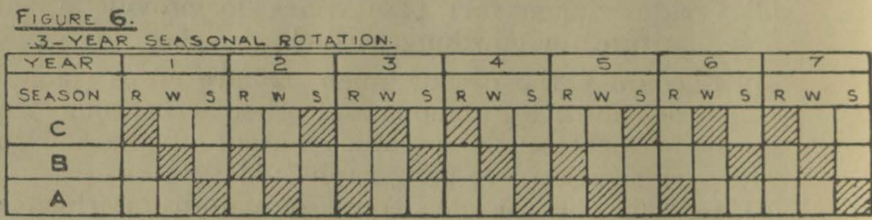
(8) Stop common grazing by dividing up the village common land into plots allotted to families or houses, so that some individual responsibility may be created in checking over-grazing. The limiting factor for such a scheme is almost invariably the water-supply, which can seldom be distributed through a series of small paddocks. The success of partition of *shamilat* (common grazing) appears to depend directly upon whether there is a real land-hunger which forces people to work hard on improving the land allotted to them.

Rotation of closures.

8·8. The chief aim of rotating is to give each part a chance of regenerating itself with grass and other palatable plants. The simplest form of rotation is to divide the available land into two and graze half each alternative year. Another easy rotation is to divide in three and give two years' rest to each part in turn, and this is better in that it gives a better chance for rested areas to produce a grass crop fit for

cutting but the open one is of course likely to deteriorate from over-use. Another alternative is to have three blocks and use them all each year but change the sequence of opening as is shown diagrammatically in figure 6.

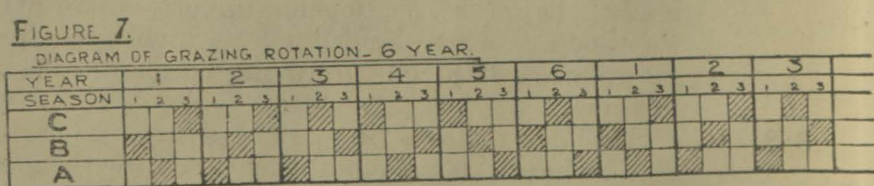
Fig. 6. Simple 3-year seasonal Rotation.



This ensures for each block a 16-months' rest after the monsoon closure, beginning with block C. Seasons R, W and S indicate rains, winter, and summer.

If the grass has been damaged and reduced by prolonged misuse, and it is essential to produce plenty grass seed, a 6-year rotation is recommended as in figure 7.

Fig. 7. Diagram of Grazing Rotation—6 year.



Seasons 1, 2 and 3 indicate winter, summer and rains. Thus C, which is given the first chance of regeneration, is

grazed in the autumn in years 1 and 2 and in mid-summer in year 3, by which time the seedling crop of the two previous years should be well established. In years 3 and 4 B is grazed last, and in year 5 second, after which A is given its chance to regenerate. The seventh year is the same as the first thus making a 6-year cycle.

Length of Forest Closures.

8.9. Where forest tree growth for timber crops has to be considered, such short rotations are of little use, because 10 years' complete closure is about the least time required for chil pine seedlings to take root and grow out of danger and even this is too short for deodar or ban oak. The 10-year closures used in Kangra scrub forests have shown that the common broadleaf species do not grow enough in that time to be out of danger from goats and cattle.

Water for Livestock.

8·10. An adequate supply of good water is as essential to livestock as is forage. The shorter the distance between watering points the better, and every opportunity should be made for developing and improving the supply by building up a reserve in tanks or pits. The windmill pump now used almost universally in the United States is cheap and fairly simple to install ; this would be a sound investment for any community in windy foothill country whose usual supply is a seasonal stream which is liable to dry up in the dry season. In the foothill grazing grounds the pools in the main streams gradually dry up as the dry season advances, so that the hotter the weather and the weaker the stock from scarcity of fodder, the farther they have to go in search of water. This can be reduced to some extent by building a series of low walls or checkdams across the stream-bed which will increase the permanence and number of reliable pools.

Water-saving Dams.

8·11. Such treatment of smaller nala beds should not be expensive as there is usually an ample supply of big boulders at hand. A rough dry-masonry dam with a broad base and sloping face can be made fairly water-tight with a puddled clay face. The height of each dam should not be more than a few feet, say, maximum 12 feet, because anything larger would interfere with floods and probably be breached. The main object should be to make a long series of small dams which will give a terraced profile to the stream-bed above the point where the water-catching dams are to be built, rather than build fewer and bigger dams. Such work should be combined if possible with grazing rotation or grass-cutting closures upstream so

that floods and the amount of erosion debris deposited may both be reduced. If this is not done the storage spaces behind the dams will of course be quickly reduced by deposits of sand and silt. Treatment along these lines will not only provide permanent water ponds for the livestock but will also improve the water-table level in neighbouring fields owing to the increased amount of seepage from the river bed.

Grass as a Crop.

8·12. The areas usually reserved for grass-cutting are those which are too poor, too steep, or too rugged for cultivation, so that on the whole they have very bad soil. The grass-cutting season also has to wait until the autumn harvest work is over so that the grass is generally over-ripe and dried up before it is cut, so that it has lost much of its nutritive value. For both these reasons therefore the grass is poor in quantity and quality. Chemical analysis shows it to be of very poor nutritive value.(2) To compensate for the lack of minerals in the ration, block salt with some salts of phosphorus and calcium added should be given as a lick. "Churn" brand mineral flour is prepared by Imperial Chemical Industries both as a powder and as a "lick brick".

Manuring of Fodder Crops.

8·13. Wherever manure can be spared, manuring of grass plots gives most valuable results This could easily be done where at present the droppings of kine and buffaloes in their summer stamping grounds far from the village are not used for any purpose. Every opportunity should be taken to produce more fodder crops wherever this can be done without causing a serious reduction in the output of cereals for human food. The use of leguminous crops such as shaftal has been recommended for sowing in fallow fields (paragraph 7·11).

Contour Ridging of Pasture Land.

8·14. Grass, like every other crop, depends on moisture, and the poor grass yield is due quite as much to lack of moisture as to poor soil, because even in the good rainfall areas the grass slopes do not catch their fair share of rain. This could be remedied by going in for intensive *watbandi* of grass-lands wherever the average slope is less than 1 in 6. Each ridge cut out of the hillside would have to be carefully marked out so that it runs dead level along the hill. Sections of 20 to 30 feet in length should be separated by transverse bunds so that any accidental breach will drain off only a small length of water. On ground steeper than this and open to grazing, ridging or trenching would probably be worth while, but further experiments are required before this can be recommended.

On all gentler slopes, however, it can safely be recommended, and if a good grass seed is sown at the time the ridging is carried out, this will give it a good start against weeds. The collection of grass seed locally may prove expensive and many grasses have a very poor germination capacity, so that commercial seed may have to be purchased.

Lantana Pest.

8·15. The ploughing and resowing of natural grass-lands is receiving a great deal of attention in Britain and South Africa and would undoubtedly be worth trying on more level land, such as the gentler slopes in Kangra Valley, which are now being invaded by the *Lantana* bush. This bush is a real pest in many parts of India with a higher rainfall than the Punjab and has only come into the Kangra grazing lands because the natural grass growth has been so seriously weakened by heavy and continuous grazing. The best way to eradicate it is to uproot and burn the bushes, plough the land into contour ridges, and resow it with a good grass seed, then reserve it for some years for grass cutting instead of grazing. Hill sides which have already been terraced for cultivation but which have since been deserted should be repaired so that the terraces will catch and hold water for grass improvement.

Silage.

8·16. The making of silage as an additional source of food when pasturage is not available should be far more widely employed than it is. For big estates, the pit should be dug with vertical sides and sloping ends, so that the carts bringing in the green matter can be driven into it to unload, consolidating the whole lot under them as they do so. For small-holders the Agricultural Department recommends smaller circular pits with vertical sides because air can be excluded more easily and the percentage of wastage is lower. As a rule planted crops, such as maize and sorghum, are used for silage, but excellent results can be obtained by using any of the coarser grasses, and cutting them before they reach the flowering stage. Good pit silage was made by the Military Grass Farm at Dehra Dun in the United Provinces with Johnston grass (*Sorghum halepense*) which is a troublesome weed there. Silage is not in itself a balanced ration and it usually requires some hay to make it complete.

Goats and Sheep.

8·17. Sheep are much less destructive than goats to bushes and trees, and for this reason are preferable to goats, but unfortunately goats' meat is preferred to mutton by most Punjabis and except where a good market for sheep's wool has developed, the goat is still preferred. As a means to encourage the

displacement of goats by sheep the use and marketing of wool and the marketing and eating of mutton should be encouraged.

Migrant Gaddi Flocks.

8·18. In the high hill pastures above 10,000 feet there is a great natural resource of grass-lane which can only be harvested by means of sheep-grazing because it is not possible to have it cut or used in any other way. The large herds of sheep which use these alpine pastures in the summer have to be provided with winter grazing in the foothills, and they therefore clash badly with the local resident animals of the lower hills, where the winter grazing demands are exceedingly heavy. The *tirni* tax collected by Government in Kangra has been increased on goats in order to encourage the migratory Gaddies to keep more sheep and fewer goats. Any local attempts at regulating or restricting this grazing naturally fall most heavily upon the non-resident flocks which are liable to be squeezed out by heavy taxation, particularly in the case of Indian States, and it is therefore desirable that the needs of the migratory flocks should be provided for. The presence of these large migratory flocks is, however, a great temptation for the breaking of forest land, because they form a cheap and easy means of manuring land which could not be manured at all in the ordinary way by carrying out cowshed litter from the village. There is also a growing tendency for individual Gaddi shepherds to give up their migratory movements and settle permanently in the lower hills, but in order to do so they have to reduce their sheep in preference to goats, because sheep cannot remain so healthy in the foothills during the heavy East Punjab monsoon as goats can. The provision of winter grazing for these migrants would not be difficult if the resident livestock of all species could be reduced to reasonable proportions, and this should be the main aim of any control measures rather than the elimination of the migrant sheep.

Improving Sheep.

8·19. The attempts of the Veterinary Department to improve the breed of sheep through the introduction of Merino and Bikaneri ram should be properly co-ordinated with the question of available grazing. When a countryside such as Kangra is already overrun with far too many livestock of all kinds, and shortage of fodder is really acute for a part at least of each year, it does not appear to be sound to produce crossbred animals which have admittedly less resistance, and need more as a minimum ration, than the local sheep. The first obvious step is to bring the total head of livestock down to what the land will support; improvement of the breed can then be

taken up with some hope of success. The reduction of cattle is bound to be a very slow process in face of the deep-seated religious objections to the taking of life.

8·20. Suggestions for improvement in goat-farming methods are given below :—

Suggested Improvements in Goat Farming.

(*i*) Rotation of grazing is even more important for goats than for cattle because their favourite browse plants take longer to recover than grass does. Goats eat more browse in winter than in summer and for part of summer can be kept entirely on grass.

(*ii*) Provision of good water at frequent points in the range is essential.

(*iii*) In seasons when both browsing grounds and grass supply are poor, other foods, such as grain should be given. A useful emergency ration is *Opuntia* (*taur*) from which the prickles have been burned off ; in the Bombay Deccan the spineless Cactus (*Opuntia decumana*) has proved immune to cochineal insect attacks and is used as a fodder.

(*iv*) Where the vicinity of the village is over-grazed herds should be bedded for the night at distant points inside a temporary fence.

(*v*) Rock salt should be fed in the bedding ground.

(*vi*) Segregate the bucks entirely from the herd of does except for 40 days at each breeding season, and even in the breeding season they should be grazed separately in day time.

(*vii*) Select only the best bucks for breeding.

(*viii*) Provide extra browse and grass for does for two weeks previous to mating, and at time of kidding.

(*ix*) Provide shade and protection from rain and wind for kids which should be tethered while the mothers browse.

8·21. The buffalo is deservedly popular for its heavy milk yield, but it is obviously not suitable for extensive grazing and must be largely stall-fed. This has not been fully realized and in many districts buffaloes are grazed with the rest of the cattle and are consequently miserable bony creatures who give a poor milk yield. A certain amount of grazing and exercise is advisable but they must be well fed. Indiscriminate buffalo grazing should be stopped, particularly during the monsoon, when their weight compacts and puddles the ground into a hard stiff clay, or breaks down steep slopes and so destroys the plant cover. The buffalo thrives on tree loppings and the planting of suitable fodder trees such as *palach* (*Populus ciliata*) should be encouraged to increase the fodder supply (see paragraph 9·6). The lopping of such trees must however be controlled so that the trees are not destroyed but are kept permanently productive.

Buffaloes.

8·22. The Cattle Conference of 1937 has recommended very strongly that each province appoints a local standing sub-committee for fodder to keep in contact with the Central Fodder and Grazing Committee of the Imperial Council of Agricultural Research. The local committee should include a forest officer, an animal husbandry officer with knowledge of local stock problems, and a botanist with a detailed knowledge of *wild* fodder grasses. One of the first duties of this committee will be to carry out a rough survey of the potentialities for fodder production from all uncultivated land, irrespective of whether it is at present held by the forest (or other government) department, private ownership, or village waste.

Fodder Survey.

On the lines already being employed in South and East Africa and in America, where the grazing industry is in a bad condition the fodder production of uncultivated land can be very greatly increased by one or more of the following methods of treatment :—

(1) *Grass-lands*—

(*a*) Closure to grazing for a part of each growing season to allow the grass to recover.

(*b*) Rotational closure by grazing in alternate blocks each month or each year.

(*c*) Substituting grass-cutting for grazing on land that will give a crop worth cutting.

(*d*) Contour ridging to catch run-off and improve seepage of water to grass roots.

(e) Sowing and cultivation of improved strains of local grass or of foreign imported kinds which will give a better yield or keep green longer on the ground.

(f) Counter-erosion work on land at present unproductive because ruined by sheet erosion and gullying.

(2) *Tree-bearing lands*—

(a) The regulation of lopping of fodder trees to provide a sustained yield from suitable areas of broad-leaf forest.

(b) Planting and sowing of tree species valuable for fodder.

(c) Efficient protection of such areas once established.

Erosion Control Produces Fodder.

8·23. Amongst the objects of the Fodder Survey should be, to locate and classify all land capable of growing fodder, and outline what action is desirable along these lines. For instance, the cost of contour ridging or other counter-erosion work would be more fully justified if spent on land of a class which would yield a good immediate return in grass. Similarly out of the large areas of broad-leaf forest already degraded by destructive lopping, some is already ruined and will take many years of protection to recover, whereas much has still got sufficiently good soil left to produce immediate results if planted with fodder trees. Owing to less frost and a heavier monsoon, the Eastern Punjab foothills will repay attention better than will the Western half, where grass and tree growth is slower and choice of species is more restricted.

CHAPTER IX—Forest Management as affecting Agriculture and Land Reclamation.

Village Forest Control.

9·1. The need for closer attention to forest management in village lands has been out-lined in Chapter V above and in Sir C. C. Garbett's *Forest Committee Report* (9). Previous attempts to hand over to the villagers executive charge of existing forest have proved a complete failure and the popular impression amongst trained foresters thus is that village control means inevitable deterioration. The real trouble has been that all such transfers of control have been made precipitately without any previous effort being made to teach the villager the extent of his responsibilities in forestry matters. The result has been that the *guzara* forests of Rawalpindi and elsewhere have deteriorated seriously and almost in direct ratio to the pressure of human and animal population on the forest fringe. The outer fringe is naturally the area with which the villagers are most concerned, and intensive misuse of this outer belt by grazing and promiscuous attempts at cultivation inevitably roll up the fringe through gradual disforestation and in time the whole weight of the zamindars' demands for timber, fuel, fodder and grazing fall upon the reserved forests, so that Government can no longer make any cash revenue from these reserves.

Villagers need Instruction.

9·2. On the other hand some form of village control and responsibility is very desirable, if only to do away with the unpopularity which the Forest Department inevitably earns through its efforts to conserve this outer fringe of hard used forest in face of the villagers' natural opposition to what they consider is interference with their own established practices and needs. But before any transfer of charge is made, it is absolutely essential that the villagers should be taught the simple facts of forest management—i.e., treat the forest as a bank, not as a mine ; the time required to grow a tree ; the conditions needed for getting young growth to replace fellings ; the damage to trees and soil caused by fire, heavy lopping, over-grazing, and other misuse ; economical use of timber in house buildings ; the value of forests in conserving water supply. Once the responsible villagers have grasped these essentials, there is some prospect of getting them to face their new responsibilities in a proper spirit, but until they have done so it is safer for all concerned to keep all the forests under direct departmental control. The first step must be education, the last step transfer of authority, but in all attempts made so far in the province this procedure

has been reversed with inevitable destruction to valuable forests. Every available channel for publicity, namely, Rural Reconstruction and Co-operative departments and local schools should be made use of in teaching forest protection before fresh responsibilities are delegated to the people.

Co-operative and Panchayat Management.

9·3. Even the most successful attempts at *panchayat* forest management in the United Provinces (Kumaon) and in Bombay are a long way behind the example set by Swiss and French village communities where every man is so vitally interested in every detail of the working of his village forest that it forms a natural training ground for other co-operative activities. The potential value of village managed forests both in this direction and as a means of meeting land revenue and other expenses is enormous. In order to put this into practical effect the *panchayat* and co-operative branch officers in forest districts should associate much more closely with the local forest staff who should in turn be prepared to help them much more than they have done in the past. The details of each individual forest can best be worked out by the *panchayat* or co-operative officer and the divisional forest officer, when they are assured that sufficient progress in education has been made to justify transfer of powers to the village. Progress made along these lines in Hoshiarpur district is summarized in Chapter XI.

Lopping for Fodder and Litter.

9·4. A peculiar feature of Punjab animal husbandry is the dependence in many localities upon tree lopping for fodder. In the oak zone of the lower hills at 4,000 to 6,000 feet, *Quercus incana* and *Q. dilatata*, in the higher hills, *Q. semecarpifolia* and in the more arid hills *Q. ilex*, are all lopped heavily ; in fact one or other is being completely driven out and destroyed over large tracts, for example, *Quercus dilatata* in the Murree hills, *Q. incana* in Kangra. The same thing applies in a still lower zone where *Olea cuspidata*, the wild olive, or *kao*, still persists in face of very heavy misuse in the limestone and sandstone of the Jhelum Salt Range and other arid hilly tracts below 3,000 feet altitude. The combination of persistent grazing, browsing, and lopping under an exceedingly arid climate is more than even this hardy species can stand, and it is disappearing from a landscape already devastated by erosion. The presence of fine old *kao* trees in graveyards throughout the Frontier show that at one time it formed a complete forest over many of the foothill valley floors. Many similar instances could be quoted for the less arid tracts in the other

districts enumerated above; the processes of desiccation, deforestation and inevitable erosion can be seen by any intelligent observer. Heavy lopping contributes towards this in many places, besides being the means of destroying the beauty and shade value of many fine roadside avenues.

Responsibility of Tree Owners.

9·5. Much of the latter form of damage is done by wandering Gaddis and other migrant owners of flocks in the plains, and better policing and heavier punishment when caught appears to be the only means of preventing it; the responsibility for preventing it lies with the owner of the trees and this may be the Buildings and Roads Branch, the Irrigation Branch, a District Board or some other local body, so that no general action can be taken.

NOTE—It is now the accepted policy of Government that the Forest Department should gradually take over the responsibility for all roadside and canal avenues (1946).

Planting for Lopped Fodder Supply.

9·6. For damage by local residents a more constructive policy can be adopted by making a definite provision for lopping in suitable forest areas and insisting upon a definite rotation so that each tree may have a fair chance of recovering and throwing out a fresh canopy of leaves. For oak a minimum of three years is required; for olive probably five years. Where the lopped species are scarce or are dying out as a result of previous ill-treatment, a regular planting scheme should be drawn up and small blocks of the area planted with this or another suitable species, but for this fencing and closure for a number of years is essential. Scattered trees planted in grass-cutting reserves will add greatly to the value of such areas. The oaks are difficult to raise as seedlings but there are many other species suitable for lopping which are easily raised, e. g., *simul* (*Bombax malabaricum*), *biul* (*Grewia oppositifolia*) and *tut* (*Morus alba*). (See also paragraph 8·21 for poplar leaves as a buffalo feed.)

Lopping of Conifers.

9·7. The lopping of coniferous trees, chiefly blue pine or kail, and spruce, is a much more difficult problem, partly because it occurs in less accessible areas, partly because larger branches are cut in order to provide manure by burning them in the fields. Both species are also much used for litter, laying them on the cowshed floor until saturated, then putting them out in the fields. In the case of the blue pine there is unfortunately a very common and destructive fungus which finds entry to the wood through any exposed wound and eventually rots the whole heart of the stem. The chief agencies for causing wounds are lopping of branches and browsing of young shoots

by goats, and until both acts are controlled there appears to be little hope of reducing this disease, which occurs almost everywhere in the blue pine forests, though more destructive in certain places, e. g., Kulu, Seraj and Mandi State. This particular disease does not affect the spruce to the same extent, but other fungus rots do find entry to its wood in this way, so that lopping of both trees is most undesirable. The cure appears to lie in teaching the hill villager to make more and better manure by composting all available rubbish from field weedings, etc., as outlined in paragraph 5·12, and in stricter control of lopping where this can be exercised. Unfortunately lopping has been admitted as a right under certain forest settlements (e. g., Kulu and Bashahr) and although a height limit has been laid down (generally ½ or 2/3rds the height of the tree) such restrictions are almost impossible to enforce (See paragraphs 5·9 to 5·11 regarding rights of user)·

Demarcated Forests.

9·8. Throughout most of the two provinces demarcation and subsequent protection have been effective in preserving existing forests in more or less the condition they were in at the time of demarcation. The Bakharar forest in Hamirpur and the Lohara forest in Hoshiarpur have improved so much as the result of 50 years' closure of what was previously waste that the nala beds of their streams have been appreciably reduced in width. On the other hand water conservation values have been undoubtedly harmed by heavy grazing. From other points of view which are covered by the forest working plans and include sustained yield of timber and fuel, and the regeneration of sufficient young trees to replace the old stock, the position on the whole is satisfactory, in view of the enormously heavy demands which have been and are being made upon them by the right-holders and other local population. Certain areas, however, have suffered so severely that they no longer produce any forest trees nor are they fulfilling any useful role in flood control or fodder production. Examples of this are to be found in the Salt Range amongst both reserved and unclassed forests and in the reserved rakhs near Rawalpindi. The Kwara and Zira forests west of the Indus were recommended for closure and protection in 1910 but nothing was done with the result that some 40,000 acres have been laid completely bare in 25 years. (Authority Mr. R. N. Parker.)

Cultivation on Lease.

9·9. Where half a century of so-called protection has failed to check deterioration and the demarcated forest has been reduced to

almost the same unproductive level of devastation as the adjoining village lands, these demarcated areas merely serve as a stamping ground for a forest guard to collect illicit grazing money. By handing over control to a co-operative society or *panchayat* which would act under the advice of the local forest officer, such areas can be made more productive and useful, provided particular emphasis is placed on the role of water conservation which was the ostensible reason for their reservation originally under the Forest Act. Without altering either the classification of the land or the forest settlement, it should also be possible to try the effect of intensive contour ridging and terracing. This would be done cheapest in the better soil areas by allowing cultivation by individuals on lease, either for field crops or grass, but in order to get this terracing done, the lease would have to be long enough to guarantee the lessee some return for his labour, say, 10, 15 or 20 years. Grazing on the remainder of the area would have to be controlled, either by rotation or by an agreed partition amongst the rightholders for the same period.

Revision of Settlement.

9·10. The question of revising the forest settlement has been brought up repeatedly by civil officials in the Salt Range and elsewhere, and it is generally found that revision proposals are aimed chiefly at ground such as is discussed above, where half a century of Forest Department protection has failed in its object. It would be more logical to attempt alternative plans for improvement, on the lines now suggested or by any other means, before attempting any radical reclassification of the land. Reclassification of the land in its present condition, or a reassessment of rights and demands under the present regime of gross over-grazing, could only lead to disforestation and the complete loss of administrative control. The main object of reservation was originally conservation of the existing forest growth for flood control and other reasons of amenity, and even if the area has deteriorated seriously from its early condition, this is no reason why further attempts should not be made to restore the land to an efficient condition for soil and water conservation as the primary object, all permissible uses of the land being considered and tried with this end in view.

Need for Village Plantations and Shelter-belts.

9·11. Small blocks of woodland owned by the community or by individual families are a feature of many really flourishing agricultural communities. As a purely agricultural improvement the planting of

trees is most desirable for a number of reasons, the most important being that they provide a fuel supply to replace the burning of cowdung. In addition they serve as shelter-belts which reduce damage to agricultural and fruit crops from hail and desiccating winds, while individual trees are invaluable as shade and shelter for livestock. There is a common prejudice against growing hedgerow trees on the borders of fields owing to the poorer yield of farm crops in the shade of most trees ; in view of this quite natural prejudice it is preferable to have trees planted in blocks or plantations rather than scattered indiscriminately, though wherever this prejudice is not too strong, the growing of hedgerow timber should also be encouraged. Where individual holdings are too small to permit planting of blocks part of the common land should be used for this.

Protection Essential.

9·12. In the Western Punjab and Frontier arid foothills the growth of grass in *dakha rakh* is considerably better under light shade of trees such as *phulai* (*Acacia modesta*) than it is in the open, so that tree planting in such places meets a dual need. In areas of better soil where tree growth is more rapid, the supply of leaf mould from nearby forest land is of importance in supplementing the manure supply. The supply of fodder can also be improved by growing trees suitable for lopping, but if lopped they obviously will yield less leaf manure.

The main danger in establishing village plantations is that grazing and browsing will not be properly controlled. Some trained supervision is therefore advisable. For successful plantation work it is absolutely essential that all livestock be kept out until the young trees are out of reach of the animals, and that goats in particular be kept out altogether. In the more arid climate of the Western Punjab it is better to keep plantations closed entirely to all grazing owing to the serious damage done by animals in compacting and pulverising the soil, thus preventing the trees from building up the porous forest soil which is essential to their proper growth. It must be realized that uncontrolled grazing renders forest plantation work impossible, though forestry combines well with almost every other village activity.

American "Woodlot".

9·13. The individual farmer's forest block, known in America as a " wood-lot ", finds its duplicate in the Jhelum Salt Range and in Gurgaon where partition of the common *shamlat deh* has led to the proper protection of jungle growth in the uncultivable part of each man's holding. Such private

holdings are most valuable in producing grass, tree fodder, fuel, timber, and leaf mould for manure. Mr. McConnachie when Deputy Commissioner, Gurgaon, once punished a man by making him enclose and plant a piece of his own ground. In twenty years' time the owner sold the trees from this area and realized enough cash to marry off a son and a daughter. This lesson should be more widely applied by the official encouragement of village afforestation either by the community or by individuals. Tree plantations are a sure road to rural security and a better balanced village economy.

Stream-training within the Hills.

9·14. In typical torrent-ruined land there are always considerable flat areas in the bends of the torrent bed before it debouches from the hills. These can readily be reclaimed by putting in live hedges of *nara* reed (*Arundo donax*) and *banha* (*Vitex negundo* ; *marwan* in Jhelum) which act as combs to catch part of the flood water and make it deposit its silt in the enclosed bay. Provided a good thick hedge is maintained along this edge, and the floods from upstream are reduced to some extent by grass-land closures and afforestation, there is no reason why such reclamation should not be permanent. This border hedge can be made to produce a good income from the planting of bamboos, tun, harar, shisham, oranges, and other fruit and timber trees, and the fields behind this screen will be of good quality owing to the nearness of the water-table in the *cho* bed. One danger is that the natural bends of the stream may be foreshortened into a straight line, so care should be taken not to straighten the course but to preserve the natural curve of bends and meanders. Foreshortening the stream entails a more rapid fall per mile of length and therefore a greater potentiality for bank erosion and the carriage of silt.

Stream-training outside the Hills.

9·15. For controlling a stream after it has debouched from the hills into the plains, some form of bund along each bank is required to confine the stream to a given bed, but high earth or stone bunds should be avoided. Particularly when the stream is still liable to carry down and dump heavy loads of silt, and so raise the level of its own bed, bunds are almost certain to be either breached or overtopped sooner or later. It is therefore better to depend on a series of live hedges which will act as combs to catch silt and gradually build up terraces along each bank. These hedges are made by digging a trench and putting in it *banha* branches and *nara* roots, preferably after winter rains so that the sprouts will

have taken a firm hold of the ground before the monsoon floods test them severely. The alignment of these hedges should be parallel with the direction of the stream, or at an angle of not more than 25 degrees to the line of flow, so that they tend to confine the stream gradually to a narrower strip without offering direct resistance to the current. To start with, the stream should be allowed plenty of room, but year by year fresh trenches can be made to reduce the width ; once *banha* is established a fresh line of hedge can be formed on the streamward side by bending down and burying live branch tips in front of the old hedge. This type of reclamation is less spectacular and takes longer than building big bunds, but it is much more effective in the long run and represents a permanent gain, provided of course that the regime of the stream has been improved by a better plant cover upstream.

Management of Reclaimed Land.

9·16. The land immediately behind the hedges or bunds should also be planted with tree growth and kept under tree growth permanently as an additional safeguard against flood damage. When it has been ascertained that flood peaks are really abating and the width between the bunds is more than sufficient, additional parallel bunds should be placed so as to reduce the stream channel still further, and this can be continued until the stream is safely anchored and prevented from further meanderings over the old flood plain. Even at this stage a wide belt of land, say, 300 feet, should be kept permanently under forest, and felling should be controlled particularly if the land is in private ownership. Beyond this protective belt the old plantations can be felled and reclaimed ground brought under cultivation. Grazing damage to the bunds must be carefully guarded against and the bunds should also be tested frequently for rat burrows, which may easily cause a breach. The value of shisham as a means of improving the agricultural value of *bela* land is dealt with in paragraph 11·10.

Technical Advice.

9·17. As regards choice of species and details of planting and sowing technique and the alignment of *banha* hedges the opinion of a trained forest officer should invariably be obtained in order to avoid as far as possible the disappointments which frequently follow unskilful attempts at tree planting and torrent-training. Picked forest guards should be appointed as village foresters for each co-operative society or group of villages in which this type of work is to be taken up. The amount of frost varies in the Punjab and limits choice of species particularly

in the north-west; fast growing trees such as *Eucalyptus* are greedy feeders and should not be used on field borders because their roots interfere seriously with crops for a wide radius round each tree.

Social and Political Difficulties.

9·18. It will be seen from the foregoing that recent advances in the technical skill of afforestation and land reclamation work have taken empirical knowledge far ahead of local performance. To those who know the Punjab peasant and realize his innately conservative outlook and suspicious objection to change, it will be obvious that this work introduces many new problems. Any change in the grazing regime immediately causes unrest and suspicion, and any suggestion about the reduction of livestock runs counter to the religious beliefs of the Hindus. The castes such as Gujars, Gaddies and Labanas who were originally itinerant graziers and have comparatively recently given up vagrancy are all bad cultivators and the standard of their field work is lamentably low. The Gujars and similar recently settled castes are usually tenants and frequently at loggerheads with their landlords.

Where bad field technique is common it can generally be traced to a short lease which allows the tenant no security of tenure, or discourages him from making improvements such as *wattbandi* lest the rent is raised or the lea e given to a higher bidder, thus robbing him of the results of his labour. The policy of the British administration in the past has been to interfere as little as possible with the life of the peasant, and under the new regime of elected ministers there is a natural anxiety to avoid any action which will alienate votes through unpopular measures of control. There is also the difficulty of financing such works on the very wide 1,000-mile front of the foothills from a provincial budget which is dependent on the vagaries of rainfall and has many other calls upon it. This book however can only indicate the various lines of approach in the hope that some at least can be made effective. Proposals are summarized in Schedule A which follows.

Schedule A—Proposals summarized (paragraph 10·1)

Ploughland.

(*a*) *Watt-bandi* and terracing; improve where already in use and introduce where unknown.

(*b*) Remission of revenue to encourage *watt-bandi*.

(*c*) Consolidation of holdings to facilitate planning of field layout.

(*d*) Planning and proper terracing of field drains.

(*e*) Co-operative loans for land improvement.

(*f*) Use of live hedge plants and proper alignment of hedges.

(*g*) Capture and use of road run-off.

(*h*) Encourage use of compost manure and use of green-manuring crops.

(*i*) Rotation of crops and strip cropping with soil-binding crops.

(*j*) Find legume or grass crop to sow on fallow.

(*k*) Gully-plugging to stop deep erosion in and between fields.

(*l*) Improve cultivation of wasteful crops such as potatoes.

(*m*) Restriction of cultivation on very steep slopes.

(*n*) Refuse *nautor* sanctions on vulnerable slopes.

(*o*) Provide fuel supply to eliminate burning of cowdung.

(*p*) Patwaris and district civil staff to be given short courses in erosion control.

Livestock and Fodder.

(*a*) Encourage voluntary and rotational closures.

(*b*) Legislation to extend application of Chos and Minor Canals Acts to other closures.

(*c*) Partition of *shamlat* (common lands).

(*d*) Panchayat or co-operative management of grass-lands.

(*e*) Replace grazing by grass cutting and stall-feeding.

(*f*) Grass-land improvement by *watt-bandi* and water catching.

(*g*) Develop grass and hay markets.

(*h*) Green fodder crops and silage.

(*i*) Emergency fodder crops—e.g. spineless prickly pear.

(*j*) Planting of fodder trees.

(*k*) Rotation of lopping fodder trees.

(*l*) Control migratory flock movements and reduce percentage goats in flock.

(*m*) Application of cattle or livestock tax to encourage good type of milch and plough cattle and eliminate useless scrub animals.

(*n*) Reduction of surplus livestock.

(*o*) Grading up of flocks and herds by maintaining stud animals and segregating male goats, castration, etc.

(*p*) Determine palatability of local grasses and fodders.

(*q*) Feed mineral salts as "licks" to compensate for deficiencies in local fodders.

(*r*) Search for improved strains of grasses both local and foreign.

(*s*) Improve watering arrangements with dams, tanks, wells, etc.

(*t*) Develop market supply and humane killing in slaughter houses.

(*u*) Improve grading and marketing of hides.

Afforestation and other Works.

(*a*) Reclamation of ravined lands for fuel and fodder production.

(*b*) Reclamation of flat lands in torrent beds by stream training.

(*c*) Establish shelter-belts where advisable.

(*d*) Village plantations for fuel, timber and fodder.

(*e*) Planting of fodder trees in grass-lands and rotation of lopping.

(*f*) Control of *nautor* grants in village waste and scrub jungle.

(*g*) Protection of existing forest.

(*h*) Encourage village co-operative society as the unit for organizing forest improvement and protection schemes.

(*i*) Special legislation for control of vitally important catchments.

(*j*) Run-off control and contour trenching and water-catching bunds in forest land.

(*k*) Closure of dangerous landslips and their vicinities.

CHAPTER X—LAND MANAGEMENT AND AGENCY OF WORK.

10·1. The main heads under which the improvements outlined in Chapters I to IX can be summarized are given in Schedule A.

Proposals summarized.

10·2. It must be realized from the foregoing summary that erosion control in its widest aspects falls within the programme of at least five established Government departments, namely Revenue, Co-operative, Agriculture, Veterinary and Forests. This explains partly why it has not been taken up effectively by any one of them, except in so far as the newly formed Anti-Erosion Circle of the Forest Department is attempting to deal with it. The co-ordinating authority who is the Financial Commissioner, Development, under the general control of the Minister for Development, has over-ruling powers in allocating detailed responsibilities to the departments already engaged or ultimately concerned. The provincial Fodder and Grazing Standing Sub-Committee outlined by the Cattle Conference (*See* paragraph 8·22) is the nearest approach so far to any advisory body, but as its name implies it does not cover the whole field of work. It could readily be made to do so by extending its operations to include erosion control on cultivated ground, and the correlation of the work of the new Anti-Erosion Circle with that of the Agriculture and other departments.

Executive Authority.

The obvious unit for the organisation of land management is the civil district. The details for each distinct topographical unit should be incorporated in a simple working plan to be prepared by the Deputy Conservator or Extra Assistant Conservator of Forests on special duty advised by the Director, Anti-Erosion Circle, and a local committee consisting of, say, the Deputy Commissioner, or Revenue Assistant, an officer of the Co-operative Branch, the local Deputy Director of Agriculture, a representative for Animal Husbandry and at least two influential zamindars. This committee should be empowered to act as a local Land Use Authority, and pending fresh legislation dealing with erosion control can achieve some control by local application of the Punjab Minor Canals Act where the Chos Act is not operative. Both the central and local Land Use Authority bodies should be kept as small as possible to ensure rapid action.

Note—The Anti-erosin Circle is now the Soil Conservation Cirle. The Chos Act is now applied to the whole province. A Provincial Land Development Board has been proposed and this will correlate the work of the district bodies outlined above (1946).

10·3. Whatever small amount of publicity has so far been done has been through short publications and press reports prepared by the Silviculturist, and the Soil Conservation Circle, the circulation being arranged through the agency of the Director, Home Publicity, to provincial newspapers, schools, local boards and district civil officials. This appears to be the most suitable way of guaranteeing correct information on the subject, and should be continued, but a larger output, particularly in the vernacular papers, should be aimed at.

Erosion Control and Publicity.

10·4. Numerous courses of instruction for co-operative and panchayat officers and other officials connected with Rural Reconstruction have been held and lectures on erosion have been included. Further instruction on these lines about erosion and cognate subjects combined with practical field demonstrations for the benefit of the local civil, revenue, co-operative and technical department staffs, particularly patwaris, should be organized by districts, with help from Rural Reconstruction and Forest Department Staff. It is absolutely essential that the revenue cadre should have a good working knowledge of the erosion problem and its cures, so that they can support the specialist staff whole-heartedly in dealing with the villagers.

Training of Revenue Staff in Conservation Practices.

10·5. Previous to the formation of the Anti-Erosion Circle the only staff specially employed on erosion control measures have been Deputy Conservators of Forests who have been attached to Civil Commissioners for reporting on various districts and initiating special measures for fodder increase, control of grazing and reclamation of torrent-ruined lands. These officers however have had no subordinate staff for field work except in Hoshiarpur, where considerable progress has been made in replacing uncontrolled grazing with closures for grass-cutting. A short account of the Hoshiarpur developments is given in Chapter XI.

Special Staff Outlined.

Note—The Soil Conservation Circle now controls this work in Ambala, Hoshiarpur, Kangra, Gujrat, Jhelum, Attock, Mianwali and Shahpur districts, while other circles have erosion control work in Gurgaon, Shakargarh and Rawalpindi (1946).

10·6. In addition to instructing district officials about the elementary facts of the erosion menace so that they can help intelligently in the further spread of knowledge amongst the zamindars, more specialists are required to pursue the work and organise it in detail. The work is now scattered in several districts and is being co-ordinated by the Conservator, Soil Conservation

Local Staff.

Circle, who can guide Commissioners and Deputy Commissioners in drawing up projects for reclamation and better farming and carrying out a well-considered policy; under the Conservator, a Deputy Conservator or an Extra Assistant Conservator of Forests is appointed as district erosion officer and keeps in close touch with the Deputy Commissioner for the district in which work has been taken up. The details of field work can best be attended to by forest rangers or deputy rangers who have some technical knowledge of run-off problems, and of the simple engineering required for erosion control; one such ranger should be allotted to each tahsil in which work is to be undertaken and be under the district erosion officer for technical control. A small subordinate staff should act as foresters and "contact men" on farm improvement work under the ranger. Such a cadre can undertake a considerable amount of detailed erosion control under schemes already drafted, prepare draft schemes for fresh areas not yet reported on, provide the Provincial Land Development Board with local data for their survey, and act as the local keys for putting this committee's recommendations into practice in the field.

Recruiting Staff

10·7. Apart from the fact that several forest officers are already employed on this type of work, forestry is the most suitable technical training for work of this sort as it specializes upon the role of vegetation for protective purposes and teaches *extensive* land management as a whole rather than *intensive* study of a special crop, thus giving a broad view-point. For the lower posts of the cadre such as the tahsil erosion officer a forest ranger's training is eminently suitable, but for the temporary and subordinate posts it would be desirable to recruit men of, say, Agriculture B.Sc. standard or similar standing and give them a short intensive training in erosion technique. This is more or less the method followed in the United States of America for recruiting the Federal Government's Soil Conservation Service which was formed in 1933 and now controls work on both privately-owned and public land throughout the whole country.

Bund Building Projects as a Community or Rural Uplift Activity.

10·8. The following is an example of what can be accomplished by villagers with a little help and organization from officials. The Dwara Kas drains from a small but badly

eroded catchment area in the Jammu State foothills through Gujrat district where it has ruined some 6,000 acres of cultivation south of Jalalpur Jattan by leaving its old bed near that town and altering its course to the Chenab, five miles away. In 1917 this occurred and since then the zamindars affected have been petitioning Government for help. In 1937 the Deputy Conservator of Forests on special grazing duty in Jhelum and Gujrat took up the question and prepared a scheme for a bund to turn the torrent back into its old bed. With the help of the Deputy Commissioner and his staff, the zamindars of 14 villages turned out to build the bund. It was 660 feet long, 15 feet high and 40 feet broad at its base, with projecting buttresses to turn the force of the water away from the bank. This was completed in May and June and successfully withstood several sudden and severe floods in July and August. The free labour amounted to probably at least Rs. 8,000 in value and the only expenditure actually incurred by Government was for sand bags and plants, some Rs. 800 in all. The value of such work to the community is obvious, and there are almost unlimited opportunities for this type of work or similar stream-training projects in most Punjab districts, provided the people are given a good lead by officials and influential non-official residents.

Noot—The fate of this bund has since been jeopardised by neglect due to quarrels between the owners of the bund site and those whose land the bund protects, thus clearly demostrating the need for some local body with powers to overrule such disputes (1946).

Upstream Work Important.

10·9. In preparing such schemes, however, it is very desirable to make sure that some upstream control is also being applied, because downstream engineering works by themselves will never effect any very permanent improvement, and are always liable to be damaged by an unprecedentedly high flood which will again cause the torrent to change its course. Such schemes ought to be linked up as early as possible with grazing control and other run-off improvements in the upper reaches of the torrent's catchment area.

Areas of Special Importance for Water Conservation.

10·10. It has been shown in paragraphs 3.9 to 3.13 that the whole province is already suffering to some extent through failure to control the destructive acts of our impoverished and ignorant hillmen. With increased value of, and demands for, satisfactory water supplies this failure of the administration will rouse sharper criticism and a demand for action from the plains residents and townsfolk. The demand for the greatest

good for the greatest number is here so obvious that in the case of vitally important catchment areas, some early action to bring these under land use control is very desirable. In particular instances this will entail the acquisition of steep slopes under destructive cultivation and their afforestation, but if this is carefully planned it need not entail the ejection of the cultivators, provided they can be brought to alter their methods to comply with the new requirements. (If eviction is really necessary land in a more suitable area in the canal colonies should be allotted for their use). But before adopting such programmes some form of erosion survey such as has already been made for the Uhl catchment should be attempted in order to locate accurately the chief sources of erosion and sudden peak floods. The immediate value of existing forest and other plant cover should be correlated with the needs of the particular water-use project so that an accurate emphasis can be laid upon the purely water conservation value of the tract in question.

Reclamation means Employment.

10·11. In the discussion of control measures emphasis has been laid upon the need for grazing closures and it may be thought that dispossessed graziers will swell the ranks of the unemployed. Some re-adjustment will of course be necessary for these men, but the general effect will undoubtedly be an increase in employment not only for the temporary tasks of terrace and bund-building, gully-plugging, planting, etc., but in a permanent improvement in productivity of grass and field crops, the handling and marketing of these products and additional fruit and forest plantations. The eventual effect of any well planned conservation project must be to improve the employment situation in the Punjab as has already proved to be the case in the United States.

CHAPTER XI—Developments in the Hoshiarpur Siwaliks.

Siwaliks an Important Catchment Area.

11·1. The 90-mile length of the Siwalik foothills which extends from the Sutlej to the Beas is locally known as the Katardhar and averages some 10 miles in width between the outer slopes on the plains or *doab* side and the Sohan rivers which occupy the *dun* or interior valley. There are two Sohan streams, a 15-mile one draining northwards into the Beas and a 45-mile one draining south into the Sutlej. Since the natural forest cover was destroyed during last century, the many small torrent beds draining the outer slope had brought down such enormous loads of sand and detritus which they have spewed out over the *doab*, that many of them even when in high flood never reach any larger stream; the larger ones contribute about 15 per cent of the run-off into the East and West Bein drainage systems. In the *doab* about 100,000 acres of once fertile land have been swept away or buried under a load of sterile sand and in the Sohan quite as much again. It is an open question just how far the unbalanced run-off resulting from disforestation on these slopes is responsible for the fall in the water-table of the Jullundur and Hoshiarpur *doab*, though over-use by a multiplication of wells in the *doab* is the most obvious reason for its gradual exhaustion. The inner slopes draining into the Sohan are now in a terrible state through torrent action and the two Sohan streams contribute a fantastic quantity of eroded material, which I have calculated amounts to five million tons of sand and silt a year into the Sutlej and Beas rivers. The cold weather flow, which within the memory of man contributed a goodly flow of clear water to both rivers, is now negligible.

Early application of the Chos Act.

11·2. The attention of Government was first drawn to the serious condition of the Siwaliks by Mr. W. Coldstream and the forest officers Baden Powell and Moir in reports written in the 1870's, but nothing was attempted until 1902 when a Land Preservation (Chos) Act was compiled by Mr. P. J. Fagan, the then Collector. A general notification under section 3 of the Act was gazetted for the area included between two demarcated lines now known as the *beruni* or Katardhar lines, one following the crest of the Katardhar and the lower one along the foot of the hills, but placed some distance away from the plains in order to

exclude the innumerable villages which were established along the outer fringe of the hills. Between these lines the hills were closed to grazing of sheep and goats under section 4 of the Act and resident goats were evicted. Below this, unrestricted grazing and felling continued, so that the outer fringe has been completely disforested and is now in many places in a fantastic state of gully erosion. The next step was that in 1905 nine villages had one-third of their hill grazing area compulsorily closed to all grazing under section 5 of the Act, and the remaining 2/3rds was placed on a 2-year rotational grazing regime so that half was always open. In the 30 years until 1934, it was proved very clearly that closure to goats alone encouraged some tree growth but did very little to replace the grass cover, while the rotational closure was also not enough to improve the grass appreciably. Total closure had produced a reasonably good crop of *bhabbar* grass (*Eulaliopsis binata*) which is the raw material for the Jagadhri paper mills, and of fodder grasses which gave these nine villages an ever-improving income and a valuable reserve of fodder for their own use. The Section 5 complete closure is thus the only certain means of producing a plant cover which will reduce the pace of run-off and improve the seepage.

Recent Voluntary Closures.

11·3. In 1934 a new policy of persuasion was adopted and Mr. A. P. F. Hamilton was placed on special duty to encourage the villagers on the outer slope to apply for voluntary closure under section 5 for land hitherto under section 4. Action was taken wherever 2/3rds majority of the landlords applied. Up to the end of 1938 a total of some 90,000 acres had been brought under more or less complete closure on the outer slope, though at least one-third of this is in private hay fields over which the Forest Department does not exert any direct control to enforce a 12-month closure. It also includes some 6,000 acres of *bela* land in the outlying *doab* previously devastated by *cho* action and now brought under Section 38 of the Forest Act voluntarily, thereby enabling the department to begin reclamation work beyond the confines of the hills.

Note—The total area closed in the district amounts to 252,880 acres under Section 4 (browsers only) which includes 93,131 acres under Section 5 (closed to all animals) plus a further 77318 acres closed under Section 38 of the Indian Forest Act, as at March 1946.

The inner slope of the Sohan Dun was excluded from the 1902 demarcation as it was then in an appreciably better condition than the outer slope, but in the intervening 37 years destruction of plant cover has been so intensified by grazing, browsing, felling, digging of tree roots, and

unterraced field cultivation, that it is now in a much worse state than any of the outer slope except the grossly misused strip below the *beruni* demarcated line. No general compulsion under the Chos Act has since been made for the inner slope, as it is thought that compulsion should be reserved for important key catchment areas where the owners are recalcitrant and refuse to follow Government advice. There is also a local prejudice against the Chos Act because it is thought to be an irrevocable surrender of the land to Government, so that the Sohan Dun villages have shown a preference for closure under section 38 of the Forest Act.

11·4. Co-operative Societies for Cho Reclamation

As a result of a recommendation by the Punjab Erosion Conference of 1936, special Co-operative Branch personnel were posted in November, 1938, consisting of an inspector and 6 sub-inspectors to Hoshiarpur district and an inspector and 4 sub-inspectors to Ambala. These men were given a week's training in cho reclamation work and then allocated to groups of Siwalik villages to carry on propaganda and start societies wherever they found an opportunity. Many villages have formed an organization to make their waste land and eroded "bad lands" more productive. These two districts are already highly organized with banks and other forms of co-operative work, so it is a quite natural extension into the sphere of land reclamation. There are amazingly fine opportunities for growing good shisham forests in the flat *bela* land which is now a sandy waste, but for water conservation it is more important to improve the gullied land in the hills with grass, tree, and bamboo cover. Up to March 1946, 194 societies for village forest management and cho reclamation had been organized and registered and may more had applied for closure of their land under the Forest Act.

Previous attempts to reclaim cho land through society action have not been a great success, largely because they have not sought technical help, and in some cases have been used as a fence with which to avoid gazetted closures and keep the forest staff at a distance. In the case of Panjawar a *shamlat* improvement society was started many years ago by Mian Hira Singh, and as long as this enthusiast's influence was there, a good deal of planting work was done, but latterly the society's activities have been confined

to banking and collection of income and the early impetus for constructive reclamation has been lost. In the case of Maili village, which possesses the third largest holding of hill land of all the outer slope villages with 4,150 acres beside an additional 1,100 acres of uncultivated land outside the Katardhar line, a small revenue has always been forthcoming from the sale of grass, and one would have expected it to be amongst the first to appreciate the value of efficient closure under the Act, but instead the society clung to the exercise of its own authority in arranging grass-cutting and grazing, with the result that its revenue from grass sales per acre of holding remained poor, and large parts of this important catchment area were in a lamentably bad condition compared with the adjoining and quite recently gazetted closures of Bachoi and Lalwan. Finally in 1939 compulsion was applied and larger closures made, as a result of which the society income from grass sales has increased as follows ;—1942—Rs. 3,492 ; 1943—Rs. 7,611 ; 1944—Rs. 8,715 ; 1945—Rs. 12,392 ; 1946—Rs. 19,410. There is a good future for cho reclamation societies if they can be persuaded to accept the skilled guidance of the Co-operative staff as regards the book-keeping and office organization side of their work, and of the Forest Department staff in the technical side of cho reclamation and management of their uncultivated land.

Need for Co-ordination in Cho Reclamation.

11·5. The technique of cho reclamation is already known to the Hoshiarpur villagers who have in the past done quite a lot of planting of hedges to control the torrents, and of *kana* grass in the open *bela*, but the unco-ordinated efforts of individuals have often been beaten by the greed which allows the felling of the protective belt of dense vegetation, which must always be maintained on the banks if the stream is to be confined to a definite channel. Even where the same village owns the entire length of a cho, it is difficult to persuade those upstream to respect the needs of their down-stream neighbours where erosion control practices are concerned. There is also a fatal fascination in the construction of large and spectacular bunds, and misguided groups of villagers often undertake such projects without any technical advice. Co-ordination of effort is essential if such attempts are to be successful and permanent. The ideal organization is of co-operative societies which can depend upon the support of revenue officials and the technical help of the forest officer as well as upon their own Co-operative Branch officer's supervision. A programme including all the essential phases of cho reclamation should be drawn up for each major cho catchment on the lines of a forest "working plan" ; a start has been made with preparing these in Hoshiarpur.

11·6. Although no actual measurements of stream-flow have so far been made, a great number of observations by the local people go to prove conclusively that the old-time perennial flow which existed in many Siwalik nalas has disappeared entirely during the last 50 years. In the case of Dholbaha cho which has a catchment area of about 23 square miles in the hills the forest was never entirely destroyed and a small trickle of perennial flow persisted even when denudation was at its worst about 1900. Since then large closed areas in this *cho* have regenerated themselves naturally with chir pine and grass, and the winter flow available for irrigation outside the hills is about 3 cusecs of water. In Dholbaha the Kukanet branch, which incidentally is the best forested, is a sample of what can be done by reclamation along the stream bed, and many visitors from other co-operative societies and deputations from other districts now come here to be shown methods and results, returning to their own villages fired with enthusiasm to create a similar garden in the wilderness.

Disforestation and its effect on Springs.

In the case of other chos such as Chohal, Bachoi, Lalwan and Mahngarwal where destruction of the original cover was more complete and improvement through protection has been more recent, the sand-strewn torrent bed engulfs all moisture, but there have recently been distinct signs of a more sustained surface flow reaching further downstream within the confines of the hills.

NOTE—There has also been a marked recrudescence of the water table an shown by well levels in the plains villages of Hoshiarpur and even in the adjoining parts of Jullundur and Kapurthala (1946).

The water-table level inside and immediately outside the Siwaliks alters suddenly from place to place without any direct correlation with either the geological dip of strata or change from sand-rock to gravel or shale. In the Sohan basin the south-east or the Sutlej end of the Katardhar carries a higher and better maintained water-table than does the north-west or Beas end, and the South Sohan carries a much bigger volume of sub-soil water than does the North Sohan valley. Such local advantages are being exploited in the planning of co-operative activities where afforestation is most likely to succeed.

11·7 When the Chos Act was framed the main aim of Government was to reduce the grazing and browsing, but a better knowledge of accelerated soil erosion has since taught us that field cultivation is also a serious factor in soil

Difficulties of *Watt-bandi* and *nautor* cultivation

loss and high flood peaks. The Chos Act gives the Forest staff control over field cultivation by means of section 5-A which was added in a 1943 amendment but which has not yet been brought into operation, (1946) Efforts have recently been made to encourage *watt-bandi* practice by holding "weeks" with the help of the local Revenue, Agriculture and Co-operative staff in those villages which have much sloping land along the base of the Siwaliks, but even with their help and paying for a small labour gang to act as a nucleus for gathering voluntary labour, the response has been very poor and progress along these lines is discouragingly slow. A more effective method might be for Government to lease the "bad lands" and faulty fields from the owners while improvements such as terracing, *watt-bandi*, contour trenching, grass planting, etc., are carried out at Government expense. Such work cannot of course be undertaken over very large areas, but if demonstration blocks treated in this way are made in each group of villages the valuable lesson of complete reclamation may penetrate. In these treated blocks, cultivation by the owners or tenants should be allowed of all land which has been rendered fit for ploughing by terracing, etc., on condition that *watts* and terraces are henceforth maintained, grazing is confined to specified grazing areas, and all produce from grass-cutting, bamboos and other freshly created sources of income belongs to the owner and can be harvested by him.

Watt-bandi as part of Consolidation Programme.

11·8. Another promising line of attack is through the Co-operative Branch widening the scope of their consolidation of holdings activities to include the proper planning and maintenance of fields. It is not only the initial making of *watts* and terraces but their upkeep and repair which is important ; this can only be assured through a live co-operative organization. The district contains large numbers of brick and cement spillways, obviously introduced may years ago as a soil conservation measure, but most of them have fallen into disuse because the people have been too lazy to repair the adjoining earth bunds when these are trodden down by cattle.

Where consolidation is needed, it ought obviously to go ahead of *watt-bandi* so that *watts* may be planned for the new divisions of fields ; but there are many areas of poor *kharif* cultivation on stony slopes where consolidation is not a

practicable proposition, but where terracing and *watting* is urgently needed. Similarly with the partition of *shamlat*, many areas of eroded "bad lands" now being destroyed by common grazing could be greatly improved by partition amongst individual owners, who could cultivate what they could and protect the rest as hay-fields. The private hay-field is a useful feature in both Hoshiarpur and Kangra which has been encouraged more by partition of *shamlat* than by any other means. Partition has however failed in Jhelum because only about 10—15 per cent of the divided *shamlat* has been improved by the individual owners while the rest remained as bad as ever (1946). The three activities of consolidation, partition, and *watt-bandi* can readily be handled by the one group of Co-operative staff, and this is now being attempted in Hoshiarpur district. Previous consolidation work was confined to the more valuable *doab* villages beyond the zone of torrent damage, so that fresh areas have to be taken up by the Co-operative consolidation staff.

11·9. Sources of Village Income from Forest Produce.

On the Hoshiarpur Siwaliks the tapping of the chil pine for resin brings in an income of Rs. 1,68,000 in 1946 to villages which own chil forest; this includes a charge per blaze paid by contractors, the wages of tapping coolies for preparing, tapping and collecting the raw resin from the trees, carriage to rail-head, making of pots and lips, etc. Tapping areas have been brought under the Chos Act and village tapping contractors are licensed and supervised by the Forest Department staff.

Individual villagers make a very good revenue from their clumps of *nal* and *muggar* bamboos (*Bambusa nutans* and *arundinacea*), and these together with the solid bamboo (*bainj*, *Dendrocalamus strictus*) should be planted much more commonly than they are along the *cho* beds within the hills. They fulfil ideally the double role of a reasonably quick cash return together with effecting a barrier against torrent action, for a single clump of *bainj* can block a small gully so effectively that a level terrace of silt is formed behind its own roots.

The *Agave* is also already extensively used as a hedge plant in the district, and could be used much more widely than it is for the plugging of incipient gully heads with an impenetrable mass of vegetation. It yields a fibre which is already used to a small extent locally for ropes and string, but there should be a good future for a village industry in spinning a coarse canvas cloth from it and the pulp could possibly be used as fodder.

With prices for fodder grass ruling high in 1939 owing to the Hissar famine, grass was being taken from the Siwaliks to Patiala and other places beyond Jullundur, and the vil-

lagers realized a lakh of rupees from the sale of grass forfodder, paper-making, and thatching and by 1946 this increased to 3½ lakhs. The yield of grass per acre both for paper and fodder has been greatly increased by contour trenching, which has been done in a number of demonstration areas; the trenches catch and hold so much of the heavy but infrequent rain storms that the pace of recovery of the natural plant cover is speeded up, as compared with simple closure to grazing, and a better sustained supply of soil moisture encourages a more succulent and more nourishing type of fodder grass.

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11·10. Other existing sources of income are shisham and kikar trees. Avenue shisham 50 to 60 years old along District Board roads frequently sell for Rs. 100 or more per standing tree, and kikar from Rs. 75. There are about 80,000 acres now sandy waste in Hoshiarpur which could readily be made to produce good shisham forest. If properly established on a 15 or 20 year rotation and managed on the lines of European village forests this would make Hoshiarpur one of the richest districts in the province. The use of shisham as a means of reconditioning sandy land in the *belas* below the hills has not been appreciated ; such land becomes impoverished after a few years of field crops through lack of proper manuring, but can be brought back into good " heart " by growing shisham and *kana* grass on it for a few years. It would be in the villagers' best interests if we could persuade them to adopt a rotation of field crops and forest in which each field would go back under forest for an interval of 15 or 20 years after 10 to 12 years' cultivation. This of course is not feasible where there is an acute demand for land and a dense pattern of very small holdings, but should be quite practicable amongst the larger holdings which are common in the torrent-damaged lands of the Hoshiarpur *doab* and in Attock district.

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APPENDIX I.

Governemnt of India Circular No. 22-F., dated 19th October, 1894 on Forest Policy.

In Chapter VIII of his Report on the Improvement of Indian Agriculture, Dr. Volcker dwells at length upon the importance of so directing the policy of the Forest Department that it shall serve agricultural interests more directly than at present, and in his Review of Forest Administration for 1892-93 the Inspector-General of Forests discusses in some detail the principles which should underlie the management of State forests in British India. While agreeing generally with the principles thus enunciated by the Inspector-General of Forests, the Government of India think that it will be convenient to state here the general policy which they desire should be followed in this matter; more especially as they are of opinion that an imperfect apprehension of that policy, has, in some recent instances, been manifested.

2. *The object of forest administration is the public benefit.*—The sole object with which State forests are administered is the public benefit. In some cases the public to be benefitted are the whole body of tax-payers ; in others the people of the tract within which the forest is situated ; but in almost all cases the constitution and preservation of a forest involve, but in greater or lesser degree, the regulation of rights and the restriction of privileges of user in the forest area which may have previously been enjoyed by the inhabitants of its immediate neighbourhood. This regulation and restriction are justified only when the advantage to be gained by the public is great ; and the cardinal principle to be observed is that the rights and privileges of individuals must be limited, otherwise than for their own benefit, only in such degree as is absolutely necessary to secure that advantage.

3. *Classification of forests.*—The forests of India, being State property may be broadly classed under the following headings :—

- (*a*) Forests, the preservation of which is essential on climatic or physical grounds.
- (*b*) Forests which afford a supply of valauble timbers for commercial purposes.
- (*c*) Minor forests.
- (*d*) Pasture lands.

It is not intended that any attempt should be made to class existing State forests under one or another of these four heads. Some forests may occupy intermediate positions, and parts of one and the same forest may fall under different heads. The classification is useful only as affording a basis for the indication of the broad policy which should govern the treatment of each class respectively ; and in applying the general policy, the fullest consideration must be given to local circumstances.

4. (*a*) *Forests of which the preservation is essential.*—The first class of forests is generally situated on hill slopes, where the preservation of such vegetation as exists, or the encouragement of further growth, is essential to the protection from the devastating action of hill torrents on the cultivated plains that lie below them. Here the interests to be protected are important beyond all comparison with the interests which it may be necessary to restrict, and so long as there is a reasonable hope of the restriction being effectual, the lesser interests must not be allowed to stand in the way.

5. *(b) Large timber forests. To be managed on commercial lines subject to the satisfaction of the needs of the neighbouring population.*—The second class of State forests include the great tracts from which our supply of the more valuable timbers—teak, sal, deodar, and the like—is obtained. They are for the most part (though not always) essentially forest tracts, and encumbered by very limited rights of user, and when this is the case, they should be managed mainly on commercial lines as valuable properties of, and sources of revenue to, the State. Even in these cases, however, customs of user will, for the most part, have sprung up on the margins of the forests ; this use is often essential to the prosperity of the people who have enjoyed it ; and the fact that its extent is limited in comparison with the area under forest renders it the more easy to continue it in full. The needs of communities dwelling on the margins of forest tracts consist mainly in small timber for building, wood or fuel, leaves for manure and for fodder, thorns for fencing, grass or grazing for their cattle and edible forest products for their own consumption. Every reasonable facility should be afforded to the people concerned for the full and easy satisfaction of these needs, if not free (as may be possible where a system of regular cuttings has been established), then at low and not at competitive rates. It should be distinctly understood that considerations of forest income are to be subordinated to that satisfaction.

There is reason to believe that the area which is suitable to the growth of valuable timber has been over-estimated, and that some of the tracts which have been reserved for this purpose might have been managed with greater profit both to the public and to the State, if the efforts of the Forest Department has been directed to supplying the large demand of the agricultural and general population for small timber, rather than the limited demand of merchants for large timber. Even in tracts of which the conditions are suited to the growth of large timber, it should be carefully considered in each case whether it would not be better, both in the interests of the people and of the revenue, to work them with the object of supplying the requirements of the general, and in particular of the agricultural, population.

6. *Opening of forest to cultivation.*—It should also be remembered that subject to certain conditions to be referred to presently, the claims of cultivation are stronger than the claims of forest preservation. The pressure of the population upon the soil is one of the greatest difficulties that India has to face, and that application of the soil must generally be preferred which, will support the largest numbers in proportion to the area. Accordingly wherever an effective demand for culturable land exists, and can only be supplied from forest areas, the land should ordinarily be relinquished without hesitation ; and if this principle applies to the valuable class of forests under consideration, it applies *a fortiori* to the less valuable classes which are presently to be discussed. When cultivation has been established, it will generally be advisable to disforest the newly settled area. But it should be distinctly understood that there is nothing in the Forest Act, or in any rules or orders now in force, which limits the discretion of Local Governments, without previous reference to the Government of India (though, of course, always subject to the control of that Government), in diverting forest land to agricultural purposes, even though that land may have been declared reserved forest under the Act.

7. *Conditions on which cultivation should be permitted.*—Mention has been made of certain conditions to which the application of the principle laid down in the preceding paragraph should be subject. They have for their object the utilization of the forest area to the greatest good of the community. In the first place, the honey-combing of a valuable forest by patches of cultivation should not be allowed, as the only subject it can serve is to substitute somewhat better land in patches for sufficiently good land in large blocks, while it renders the proper preservation of the remaining forest area almost impossible. The evil here is greater than the good. In the second place, the cultivation must be permanent. Where the physical conditions are such that the removal of the protection afforded by forest growth must result, after a longer or shorter period, in the sterilization or destruction of the soil, the case falls under the principle discussed in paragraph 4 of this Resolution. So, again, a system of shifting cultivation, which denudes a large area of forest growth in order to place a small area under crops, costs more to the community than it is worth and can only be permitted under due regulation where forest tribes depend on it for their sustenance. In the third place, the cultivation in question must not be merely nominal, and an excuse for the creation of pastoral or semi-pastoral villages which do more harm to the forest than the good they reap from it. And in the fourth place, cultivation must not be allowed so to extend as to encroach upon the minimum area of forest which is needed in order to supply the general forest needs of the country, or the reasonable forest requirements, present and prospective, of the neighbourhood in which it is situated. In many tracts cultivation is practically impossible without the assistance of forests, and it must not be allowed to destroy that upon which its existence depends.

8. *Customs of user in timber forests.*—It has been stated above that the forests under consideration are generally, but not always, free from customs of user. When, as sometimes happens, they are so intermingled with permanent villages and cultivation that customary rights and privileges militate against their management as revenue-paying properties, the principles laid down at the end of paragraph 5 of this Resolution should be observed, and considerations on income should be made secondary to the full satisfaction of local needs.

Such restrictions as may be necessary for the preservation of the forest, or for the better enjoyment of its benefits should be imposed ; but no restriction should be placed upon reasonable local demands, merely in order to increase the State revenues.

9. (*c*) *Minor forest to be used chiefly for the supply of local needs.*—The third class of forests includes those tracts which, though true forests, produce only the inferior sorts of timber, or the smaller growths of the better sorts. In some cases the supply of fuel for manufactures, railways, and like purposes, is of such importance that these forests fall more properly under the second class, and must be mainly managed as commercial undertakings But the forests now to be considered are those which are useful chiefly as supplying fuel and fodder grazing for local consumption ; and these must be managed mainly in the interests of the population of the tract which supplies its forest requirements from this source. The first object to be aimed at is to preserve the wood and grass from destruction ; for use must not be exercised so as to annihilate its subject, and the people must protected against their own improvidence. The second object should be to supply the produce of the forests to the greatest advantage and convenience of the people. To these two objects all considerations of revenue should be ordinarily subordinated.

10. *But revenue should not altogether be foregone.*—It must not be supposed from the preceding remark that it is the intention of the Government of India to forego all revenue from the large areas that are valuable chiefly for the fuel and fodder which they yield. Cases must be distinguished. Where the areas in question afford the only grazing and the only supply of fuel to villages which lie around or within them the necessities of the inhabitants of these villages must be treated as paramount, and they should be satisfied at the most moderate rates, and with as little direct official interference as possible. But where the villages of the tract have already ample pasture grounds attached to their cultivation and owned and managed by themselves, and where the Crown lands merely supplement these pastures, and afford grazing to a nomad pastoral population, or to the herds that shift from one portion of the country to another with the changes of the season, Government may justly expect to reap a fair income from its property. Even in such cases, however, the convenience and advantage of the graziers should be studiously considered, and the inhabitants of the locality, or those who habitually graze over it, should have a preferential claim at rates materially lower than might be obtained in the open market. It will often be advantageous to fix the grazing demand upon a village or a nomad community for a year or term of years. The system, like every other, has difficulties that are peculiar to it; but it reduces the interference of petty officials to the lowest point and minimizes their opportunities for extortion and oppression. Where grazing fees are levied *per capita* free passes are of ten given to a certain number of cattle. In such cases the cattle which are to graze free should include not only the oxen which are actually employed on the plough, but also a reasonable number of milch cattle and calves. A cow or a buffalo is as much a necessity to a cultivator, using the word necessity in a reasonably wide sense, as is a plough-bullock, and in many parts the oxen are bred in the village.

11. *Considerations connected with the formation of fuel and fodder preserves.*—In the portions of his report which are referred to in the preamble to this Resolution, Dr. Volcker strongly recommends the formation of fuel and fodder preserves, and the Government of India has repeatedly urged the same policy upon local Governments. The question whether any particular area can be made to support a greater number of cattle by preserving the grass and cutting it for fodder, or by permitting grazing upon it, is one that must be decided by the local circumstances of each case. But when it has been decided, the issues are by no means exhausted. It has been stated in paragraph 9 above that one main object towards which the management of these minor forests should be directed is the supply of fuel and fodder "to the greatest advantage and convenience of the people." In doing so due regard must be had to their habits and wishes. It may be that strict preservation and periodical closures, or the total prohibition of grazing, will result in the largest yield both of fuel and of fodder in the form of hay. But that is of small avail if the people will not utilize the increased supply in the form in which it is offered them. The customs of generations alter slowly in India; and, though much may and should be done to lead the people to their own profit, yet it must be done gently and gradually,

always remembering that their contentment is no less important an object than is their material advantage. It must be remembered, moreover that the object of excluding grazing from the preserves in question is the advantage of the *neighbourhood*; and that the realization of a larger income than grazing would yield, by preserving the produce, only to sell it to the highest bidder for consumption in large towns at a distance for the preserve, is *not* always in accordance with the policy which the Government of India has inculcated. Here again circumstances must decide. It may be that the local supply of fuel or fodder, independently of the reserved area, is sufficient in ordinary years for the needs of the neighbourhood. In such a case the produce may legitimately be disposed of in such years to the greatest advantage, reserving it for local consumption only when the external supply runs short. Finally, the remarks regarding agency in paragraph 12, and the more general considerations that are discussed below in paragraph 13 of this Resolution , apply in full force to areas thus reserved for the supply of fuel and fodder.

12. (*d*) *Pasture land. Same principles apply as to class* (*c*) *but with greater force.*—The fourth class of forests referred to are pastures and grazing grounds proper, which are usually forests only in name. It is often convenient, indeed, to declare them forests under the Act, in order to obtain a statutory settlement of the rights which the State on the one hand and private individuals or communities on the other possess over them. But it by no means follows as a matter of course that these lands should be subjected to any strict system of conservation, or that they should be placed under the management of the Forest Department. The question of agency is purely one of economy and expediency; and the Government of India believe that in some cases where these lands are managed by the Forest Department, the expenditure on establishment exceeds the revenue that is, or at any rate the revenue that ought to be, realized from them.

The following remarks apply, not only to forest lands under the Act, whether administered by the Forest Department or not, but also to all Crown waste, even though not declared to be forest. Here the interests of the local community reach their maximum. While those of the general public are of the slightest nature. It follows that the principles which have been already laid down for the management of minor forests apply if possible with even greater force to the management of grazing areas, pure and simple.

13. *Difficulties of management.*—The difficulties which arise in connection with these areas are apt to present themselves in their most aggravated form where the tenure of land is ryotwari. In *zamindari* tracts the Crown lands generally assume the second of the two forms indicated in paragraph 10 of this Resolution. But where the settlement is ryotwari, every survey number or field that is unoccupied or unassigned is in the possession and at the disposal of Government, and trespass upon it is *prima facie* forbidden. In some cultivated tracts, these unoccupied and waste lands are the only source available from which the grazing requirements of the resident population can be met. The Government of India are

clearly of opinion that the intermixture of plots of Government land which are used for grazing only, but upon which trespass is forbidden, with the cultivation of occupancy or proprietary holders is apt to lead to extreme abuses, and specially so when these plots are under the management of the Forest Department. The inferior subordinates of the Forest Department are perhaps as reliable as can be expected on the pay which we can afford to give ; but their morality is no higher than that of the uneducated classes from which they are drawn ; while the enormous areas over which they are scattered and the small number of the controlling staff render effective supervision most difficult. It is not right, in order to protect the grass or the grazing dues on plots of waste scattered over the face of cultivated districts, to put it into the power of an underling to pound or threaten to pound cattle on the plea that they have overstepped the boundary between their owner's field and the next. Still less right it is to permit the exercise of the power of compounding offences allowed by section 67 of the Forest Act to depend upon the mere report of a subordinate servant, or to expose him to the temptation which such a power holds out. Where the interests involved are sufficiently important, it may perhaps be necessary to accept the danger of extortion while minimizing as far as possible the opportunities for it. But in the case under consideration the interests involved are trifling, while the opportunities are unlimited.

14. *Should generally be leased to, or managed through, the agency of neighbouring community.*—It is to be distinctly understood that the Government of India do not desire that grazing should be looked upon primarily as a source of income. But it by no means follows that all revenue from scattered Government lands should be relinquished. It is, indeed, inadvisable that this should be done, as to do so would give the ryots an interest in opposing allotment and making things unpleasant for new occupants. But the objections to direct management which have just been pointed out are reduced to a minimum, or altogether avoided, when the management is placed in the hands of the resident cultivators or of representatives from among them. It will generally be possible to lease or otherwise manage the unoccupied lands of a village through the agency of the community ; not, indeed, at the highest price which they are ready to pay to escape such evils as have just been alluded to, but at a moderate estimate of their value to them, fixed in view of the fact that herds and flocks, which cannot exist without grazing, are often a necessary condition of the successful conduct of that cultivation upon which the Government land revenue is paid. In no case should fields that have been relinquished be let to outsiders at a reduced assessment for grazing purposes, for then we might have speculators taking up such fields, mainly in order to make what they can out of trespassing cattle.

15. *When "reservation" and when "protection" is to be preferred.*—One more point of principle remains to be noticed. The procedure under Chapter IV of the Indian Forest Act, whereby forests are declared to be protected, has been, in certain cases, regarded by the Government of India as a provisional and intermediate procedure, designed to afford time for consideration and decision, with the object of ultimately constituting so much of the area as it is intended to retain a reserved forest under Chapter II,

and of relinquishing the remainder altogether. The Act provides two distinct procedures. By the more strict one, under Chapter II, existing rights may be either settled, transferred or commuted ; and this procedure will ordinarily be applied to forests of the first and second classes indicated in paragraph 3 of this Resolution. By the second procedure under Chapter IV rights are recorded and regulated ; and this procedure will often be properly followed where the rights to which the area is subject are extensive, and the forest is to be managed mainly in the interests of the local community It will ordinarily be applied to forests of the third and fourth classes. The second procedure may indeed be provisional and introductory to reservation under Chapter II ; but there is in the Forest Act nothing repugnant to giving it a larger and even a permanent operation. As regards Government, the chief difference between the two procedures is, that new rights may spring up in a protected but not in a reserved forest, and that the record of rights framed under Chapter II is conclusive, while that framed under Chapter IV only carries a presumption of truth. It is believed that this presumption offers ample security where the object of regulating the rights is to provide for their more beneficial exercise rather than to override them in the public interest. As regards the people the chief difference is that, speaking broadly, in a reserved forest everything is an offence that is not permitted, while in a protected forest nothing is an offence that is not prohibited. In theory it is possible so to frame the permission and the prohibition as to make the results indentical in the two cases ; but in practice it is almost impossible to do so. If it were not so, the distinction drawn by the Legislature would be unnecessary and meaningless. It is only where the public interests involved are of sufficient importance to justify the stricter procedure and the more comprehensive definition of forest offences, that the latter should be adopted.

The Governor-General in Council desires therefore that with regard both to fuel and fodder preserves, and to grazing areas, pure and simple, and especially to such of them as lie in the midst of cultivated tracts, it may be considered in each case whether it is necessary to class them, or, if already so classed, to retain them as forest areas ; and if this question is decided in the affirmative, whether it would not be better to constitute them protected rather than reserved forests.

16. *Concluding remarks.*—Such are the general principles which the Government of India desire should be observed in the administration of all State forests in British India. They are fully aware that the detailed application of these principles must depend upon an infinite variety of circumstances which will have to be duly weighed in each case by the local authorities to whose discretion the decision must be left. One of the dangers which it is most difficult to guard against is the fraudulent abuse of concessions for commercial purposes ; and only local considerations can indicate how this can best be met. The Government of India recognized the fact that the easier treatment in the matter of forest produce which His Excellency in Council desires should be extended to the agricultural classes may, especially in the case of true forest areas, necessitate more careful supervision in order that the concession may be confined within its legitimate limits. But, on the other hand, they think that in some provinces, it will render possible a considerable reduction of existing

establishment; and they desire that this matter may be carefully considered with reference to what has been said above in paragraph 12. They know also that in some provinces forest policy is already framed on the lines which they wish to see followed in all. But the Governor-General in Council believes that Local Governments and Administrations will be glad to receive the assurance now given them that the Supreme Government will cordially support them in recognizing and providing for local requirements to the utmost point that is consistent with Imperial interests. Where working plans or plans of operations are framed for forests, the provisions necessary for this purpose should be embodied in them. The exercise of the rights that have been recorded at settlement will necessarily be provided for in these plans. Where further concessions are made by way of privilege and grace it will be well to grant them for some such limited period as ten years, so that they may, if necessary, be revised from time to time, as the circumstances on which they were moulded change.

APPENDIX II.

Note on Animal Husbandry by Colonel Sir Arthur Olver

I regard this as a most valuable resumé of the various measures which should be adopted with a view to conserve and increase the fertility of the land in the Punjab, where it is clearly in great danger of being rapidly denuded if the present methods of agriculture and animal husbandry are not changed. The importance which the author has laid throughout on the necessity for dealing with these problems with the definite object of retaining the land in a condition of *permanent productivity* is, I think, the key of the whole problem, and it is in this connection that I regard the proper development of livestock in India as of the utmost importance. On the whole I agree very closely with the views of the author in regard to the great value of properly developed livestock and the great harm which may be done by inferior stock, bred and reared entirely on the wild resources of the country.

I am however unable to agree with the statement that many animal husbandry enthusiasts have failed to grasp that in the poorer districts the inhabitants have such a hard struggle to find enough land for their own food crops that they are unable to grow fodder crops. I am afraid the position is that too many have accepted this view too much to think it worthwhile trying to do anything about it. The position is in fact very well known and in my view the solution must lie in following the practice which in recent years has become more and more recognized in other countries, to be of the utmost value in increasing returns from the land and in improving fertility, namely to devote a sufficient proportion of the cultivated area to suitable fodder crops to enable livestock to be maintained on the land in such a way that none of their manurial effect is lost, bearing in mind that the urine is of approximately the same manurial value as the solid dejecta. For example in the United Kingdom in recent years it has been shown that poor denuded land which previously would grow little but gorse, heather and weeds can, in a few years, be brought by controlled grazing back to a state of comparatively high productivity. Figures are in fact available which show that with good stock and modern methods of scientific grass-land management the yield per acre over large areas has been increased four, five and even more times. Moreover it has been demonstrated in India that the same principle applies in this country. If a proportion of the land were devoted to fodder crops and if reasonably good stock were maintained on the holding, and satisfactorily fed for milk production and the rearing of improved stock, the fertility of the land could in fact be so much improved that the yield of food crops from the remainder would be more than could be obtained from the whole holding under present conditions of management. The crux of this matter lies largely in providing a satisfactory market for dairy products such as ghee. In addition to producing good bullocks sufficient additional income can be had from the sale of milk or ghee to cover the cost of the concentrates required to produce a satisfactory yield and incidentally to provide the people with a much better diet.

Another matter in which I cannot entirely agree with the writer is in the matter of the goat. I fully realize that under uncontrolled conditions of browsing the goat does an immense amount of harm to young trees, much as other classes of stock will, and that this should not be permitted. On the other hand the smaller type of stall-fed milch goat, which is kept mainly in backyards, is a valuable source of highly nutritious food and additional income and it does not seem to me that any damage done by the lopping of small twigs from large trees to feed them should be sufficient to cause denudation. According to my observations much more serious damage is likely to be done by the lopping of large branches which is regularly done by cattle and buffalo owners. For example, I can instance the Muktesswar Research Institute estate, of between four and five thousand acres, in which under proper control the forest is so dense that it is almost impossible to get through but immediately outside the boundary fence there is not a tree left and this has all been done since when the Mukteswar Institute was started. This has not been caused by goats, as comparatively few goats are kept permanently in this area, but by cows and buffaloes. As it was not the custom to grow fodder crops the grazing was soon exhausted and the only means of maintaining them was by heavy lopping of all the trees available. Now that there are practically no trees left, there is no alternative but to grow a certain proportion of fodder crops and it is likely that in this way the cultivator will be forced to produce better stock and will incidentally increase the fertility of his land. In this matter of the damage done by heavy lopping of trees for cattle, I may quote a remark made to me by Mr. A. D. Blascheck, the late Inspector-General of Forests in India, that the worst destruction of forests he had ever seen had been caused by lopping for buffaloes, not by goats.

The observation that the best cattle are bred in areas where there is practically no tree grazing is not confined to the Punjab. The position is the same all over India and, after eight years careful study, I have come to the conclusion that it would be a great boon to India if free grazing could be done away with altogether. Cultivators would then be forced to make provision for the feeding of their animals and would not keep any that were not economical. The same principle should apply in regard to common grazing around villages. The village authorities ought, in the interest of the village community, to control the grazing area so that it would be rotationally grazed in blocks and should permit only serviceable animals to be maintained in reasonable numbers. I am aware that it is extremely difficult to do this but experience in other countries shows that a great deal of improvement could be effected merely by making arrangements to conserve freshly grown young grass during the monsoon, in the form of silage as a winter reserve, and if the grazing area were divided up into blocks, and steps taken to ensure that each block would be grazed in a suitable rotation so that the whole would not constantly be trodden by a horde of useless animals wandering round in search of some means of subsistence. In certain parts of India enlightened landholders carry on a regular system of cultivation of their grass-lands and are thereby able to produce high-class stock and an increased return from the land. This is in accordance with the system of scientific grass-land management which has become so popular in the United Kingdom and other countries in recent years. The land is

broken up in blocks and after one or two grain crops have been taken it is put down to grass or a suitable fodder crop, which in the Punjab might be shaftal, and is maintained for five or six years under a system of controlled grazing. Records show that the return per acre under such a system is very much higher than where grazing land is not so carefully managed.

Moreover, systematic breeding control carried out in the villages by an Animal Husbandry Department devoted to the interest of livestock, on the lines which are followed for example in the Dhanni tract of the Punjab would, I believe, have great effect. Even though it would not be possible in areas such as the Kangra Valley to produce high grade stock, it should be quite feasible to greatly improve the local stock which, by long habituation, are better suited to local conditions than animals which have been produced in more fertile areas. If suitable instructions were given as to the proper management of livestock on the land under a system of mixed farming some at any rate would learn that this is a much more profitable system than the exclusive production of cash or food crops, which is at present leading to irremediable destruction of valuable land throughout India.

The provision of suitable mineral licks is a very effective and cheap method of improving livestock where mineral deficiencies exist and facilities should be given for carrying out analyses to determine areas in which there are serious mineral deficiencies.

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